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**2. Manuscript.** The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

**3. References and Footnotes.** Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

**4. Illustrations.** Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

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HENRI MOISSAN

# EDITOR'S OUTLOOK

IN SCIENCE, perhaps more often than in any other field, men eagerly follow problems of research to their conclusions only to have some one publish identical results just a short time before their own go to press.

**Henri Moissan**
**1852–1906**

We find ourselves interested in Henri Moissan from the beginning when we read that he was the first to obtain crystals of "carborundum," but published no account of it. And when a few years later Acheson made public his own discovery, Moissan did not push his prior claim. Some might say that Moissan had so many brilliant discoveries to his credit that he could well afford to lose the honor for one or two of them. It could be quite possible. His life is one long record of chemical achievement.

The name of this amiable Parisian has always held romance for the layman—indeed, in a way, Moissan seems a fulfilment of the alchemist's long and fruitless search. For he was the first man to make artificial diamonds.

His approach to this problem is interesting. There was a meteorite found in Cañon Diablo which, besides the large amount of metallic iron, of which most meteorites consist, had imbedded in it some minute bits of diamond. The carbon, Moissan contended, had been dissolved in the iron while the red-hot meteorite was whizzing through the earth's atmosphere. When it reached the ground, the outer surface of the meteorite had cooled almost at once. Moissan reasoned that the sudden cooling of the outer shell of the meteorite would result in a contraction, with consequent enormous pressure in the molten interior of the mass. Under such pressures he believed that carbon might crystallize from cooling iron in the form of diamonds.

Having convinced himself that this theory of the appearance of diamonds in the meteorite was highly plausible, Moissan set to work to reproduce the phenomenon experimentally. Two hundred grams of Swedish iron were fused in an electric furnace with sugar charcoal in a carbon crucible. Then the crucible was plunged into a vessel of cold water. When the iron, together with graphitic and amorphous carbon, had been removed by means of suitable reagents the final residue was floated in bromoform, in which some transparent dust, of density 3 to 3.5, sank. The transparent particles scratched ruby, burned to carbon dioxide, and showed octahedral facets.[1]

The scope of Moissan's work is too wide for us to do more than touch upon his fields of research. He studied the "interchange of oxygen and

[1] This study has recently been questioned on the grounds: (*a*) that the interior of a suddenly cooled mass of molten iron does not develop pressures of the order postulated by Moissan and (*b*) that more thorough examination of the product obtained by Moissan's method reveals considerable quantities of iron as well as carbon.

carbon dioxide in the leaves of plants which had been exposed to the subdued light of a darkened room." He was interested in the oxides of the iron group of metals, especially chromium. Five years of experimentation with the compounds of fluorine resulted in the isolation of this element. The compact metals and their carbides came under his keen observation. He prepared numerous silicides and borides. He was preeminently an inorganic chemist, and his productive research won the scientific world to favor this rather belittled field.

Here is a man who did both research and teaching and is said to have done both well. For instance, in 1891, when his investigative experiments were in full swing, he was the professor of toxicology at the École Supérieure de Pharmacie. He had been elected to that chair in 1886 and held it until 1899. In 1900, the University of Paris appointed Moissan professor of inorganic chemistry in the Faculté des Sciences.

Moissan did not go unhonored. The coveted Prix Lacaze was bestowed upon him by the Institute in 1887. In 1896, he received the Davy medal and, in 1903, the Hofmann medal. Most important, from an international standpoint at least, he was awarded the Nobel Prize for Chemistry in 1906 "in recognition of the great services rendered by him in his investigation and isolation of the element, fluorine, as well as by his introduction to the service of science of the electric oven called after him."

He was a member of numerous well-known scientific associations, such as the Royal Society of London, the Royal Institution, the Chemical Society, the Academies of Belgium, Denmark, Vienna, Amsterdam, Upsala, New York, Turin, and Haarlem.

His personality was particularly pleasing and attracted to his laboratory a vast number of promising students. He was genuinely kindhearted and tactful. He spoke fluent and beautiful French and was a remarkable expositor. He could hold the enthusiastic attention of his students throughout an hour and three-quarters of lecture. The preface to his book on "The Electric Furnace" clearly indicates his love of research: "What I cannot convey in the following pages is the keen pleasure which I have experienced in the pursuit of these discoveries. To plough a new furrow, to have full scope of study bursting upon me; that awakens a true joy which only those can experience who have themselves tasted the delights of research."

The JOURNAL gratefully acknowledges its indebtedness to Mr. Sederholm, the managing director of Nobelstiftelsen, Stockholm, Sweden, for the accompanying picture.

# ELECTROÖSMOTIC WATER PURIFICATION[1]

A. S. Behrman, International Filter Co., Chicago, Illinois

It has long been the ambition of chemists engaged in the development of water purification processes to devise chemical means for the complete purification of water—in other words, to obtain the equivalent of distilled water without the necessity for distillation.

The problem was finally solved, in its broad aspects, by Graf Botho Schwerin, a German scientist. It has remained for his co-workers and successors to develop important improvements which have made of Count Schwerin's idea a practical commercial reality.

The new process is called—not altogether accurately—"Electroösmosis." More correctly, as will be seen, the process functions primarily by electrolysis, and to a considerably lesser extent by electro-endosmosis and electrophoresis.

## Limitations of Previous Methods

It will probably help us appreciate the possibilities—and limitations—of the new process if we bear in mind the range of usefulness and maximum efficacy of other methods of reducing the dissolved solid content of a water.

The impurities in a normal water consist very largely of the bicarbonates, sulfates, and chlorides of calcium, magnesium, and sodium (and potassium).

If a water contains only the bicarbonates of calcium and magnesium—usually referred to rather loosely as "temporary hardness"—proper treatment with lime will remove these impurities bodily in the form of calcium carbonate and magnesium hydroxide, and will reduce the amount of dissolved solids in the water, whatever the initial contents, to about 50 parts per million. This residual solid content represents principally the combined theoretical solubilities of calcium carbonate and magnesium hydroxide, together with a small amount of these substances in colloidal solution.

Iron is also removed bodily from a water by lime treatment, the residual iron in a properly treated water being usually not more than 0.1 part per million. The normal iron content of waters is so small, however, that the effect of its presence or absence on the amount of dissolved solids is usually without significance.

Aside from the bicarbonates of calcium and magnesium, there is no quantitatively important group of impurities which may be removed bodily by the usual methods of chemical treatment available. True, magnesium sulfate may be removed with barium hydroxide, and calcium sulfate with barium carbonate; but these methods are practiced so seldom, because of expense, toxicity, and other considerations, that they have no importance in the present discussion.

[1] Presented under the title "Purification of Water by Electrodialysis" at the Regional Meeting at Lexington, Kentucky, October 26, 1928.

There remain then calcium sulfate, calcium chloride, magnesium sulfate, magnesium chloride, and all of the sodium and potassium salts which have hitherto been removable from a water only by distillation.

### Electroösmosis versus Distillation

The new electroösmotic process—better known commercially as the Electro-Osmose process—and distillation operate on diametrically opposed principles. In distillation, the water, in the form of steam, is pulled away from the solid impurities. In the Electro-Osmose method, the impurities are pulled away from the water.

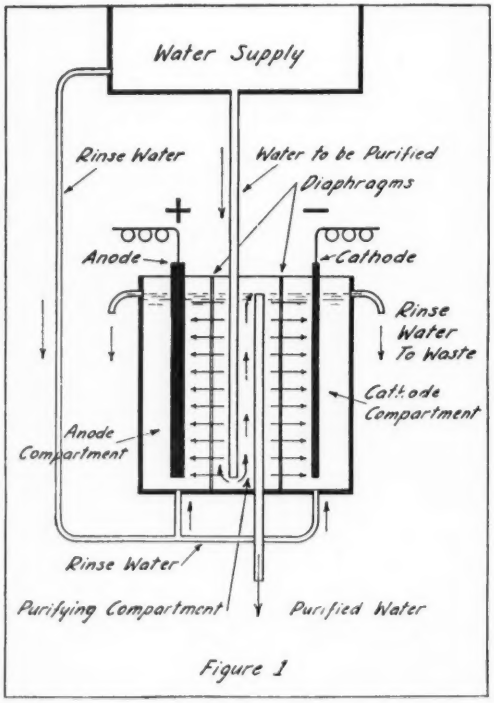


Figure 1

It is this essential difference in principle which gives to the Electro-Osmose process its great advantages of simplicity and economy of operation within the field in which its use is indicated.

### Principle of the Electro-Osmose Process

The principle of the Electro-Osmose process will be readily understood on considering the elimination from water of a typical soluble salt such as sodium chloride.

If a direct current is passed through a solution of sodium chloride, the sodium ions will migrate to the cathode, where they will be discharged and form sodium hydroxide. The chloride ions will travel to the anode where they will be discharged and liberated as chlorine.

If no provision is made for the separation of the products of electrolysis, these will react, of course, to form sodium hypochlorite.

If, however, the anode and cathode are separated by diaphragms from the liquid being purified, and if the products of electrolysis are kept from contaminating the liquid being treated, in due course the elimination of sodium and chloride ions from this liquid should be complete.

These provisions are made in the cells employed in the Electro-Osmose process. The arrangement of a typical three-compartment cell is shown diagrammatically in Figure 1. It will be seen that the water to be purified flows continuously through the middle compartment, which compartment is separated from the electrode compartments by diaphragms. In order to prevent excessive concentration of the products of electrolysis in the electrode compartments, a small flow of wash water is made to pass continuously through these compartments.

The purification of a water containing sodium chloride is shown graphically in Figure 2. It is believed that this graphic representation is sufficiently self-explanatory to require no further comment except the statement that, for the sake of simplicity, the discharged sodium and chloride ions are shown as Na and Cl and not as the products actually formed in the electrode compartments.

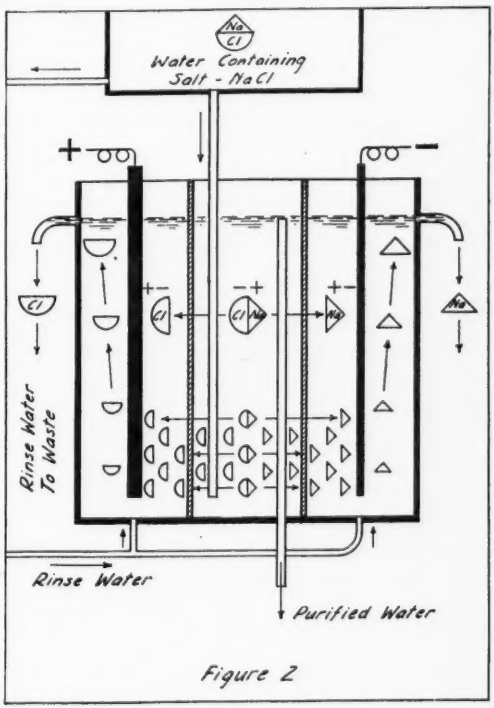

Figure 2

In actual practice, complete purification is not accomplished in one cell, but in a series of cells, such as is shown diagrammatically in Figure 3. Here the water being purified is siphoned from the middle compartment of one cell to the middle compartment of the succeeding cell. Ordinarily ten cells are placed in series.

There are several reasons why purification is not attempted in one cell. Probably the most important consideration is based on the fact that as the water becomes purer its electrical resistance increases and successively higher voltages are necessary to effect purification. It is much more economical, however, to operate at lower voltages as long as purification can be effected at these voltages. In practice, therefore, when a water is being treated for complete removal of its dissolved solid content, the electrical

hook-up is made so as to provide the lowest possible voltages consistent with the desired purification.

For example, with many waters, complete purification is carried out with a 5,2,2,1 wiring—that is, the first five cells are connected in series, then the next two are connected in series, then the next two, while only the last cell carries the full line voltage. Assuming a line voltage of 110 volts, this means that the average voltage of the first five cells is about 22, that of the next four is about 55, while the last cell has 110 volts across it.

## Electro-Endosmosis and Electrophoresis

When the Electro-Osmose apparatus is in operation, there is a definite and appreciable flow of water from the middle compartment through the cathode diaphragm to the cathode. This is true electro-endosmosis.

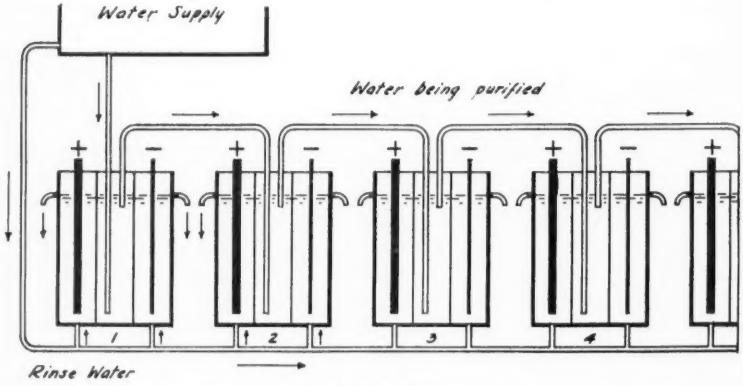


FIGURE 3

We have observed also that, when certain slightly turbid raw waters are treated with the Electro-Osmose, the effluent water is sparklingly clear. This effect is of course due to electrophoresis, by reason of which the charged colloidal particles causing the turbidity are made to travel from the middle compartment to the electrode chambers.

## Degree of Purification Possible

By means of the Electro-Osmose process, carried out in the modern equipment available, it is readily possible to reduce the salt content—and in this term is included any ionizable compound or any particle carrying, or capable of being given, an electric charge—to well within the United States Pharmacopeia permissible maximum of 10 parts per million. For the past two years all of the "distilled water" required for our laboratory and other technical purposes has been supplied by a laboratory Electro-Osmose apparatus.

The raw water, which is taken directly from Lake Michigan, has a dissolved solid content of 140 to 150 parts per million. The effluent from the Electro-Osmose unit has a total solid content of 5 to 6 parts per million. Tests we have made on other waters containing as high as 1000 parts per million have demonstrated that purification can be accomplished satisfactorily with a maximum of 10 parts per million of dissolved solids in the purified water.

## Partial Purification

To meet the pure water requirements of some industries, it is not necessary that the total dissolved solid content be reduced to the 10 parts per million specified by the United States Pharmacopeia. By changing the wiring arrangement of the Electro-Osmose series, and by altering the rate of flow of water through the apparatus, it is possible to deliver an effluent of any desired degree of purity.

The production of partially purified water is generally considerably more economical than that of completely purified water, for the reason already pointed out that the purification may be carried out with lower voltages. A specific illustration of this may be found in the fact that to purify completely a water with an initial total solid content of 150 parts per million requires the expenditure of about 50 kilowatt hours per 1000 gallons, while the purification of the same quantity of water from an initial dissolved solid content of 300 parts per million to a residual content of 150 parts per million—a reduction of 150 parts per million in either case—requires only about 15 kilowatt hours.

## Cost of the Electro-Osmose

Within its field of usefulness, the Electro-Osmose compares very favorably with distillation, both in its installation and operating costs. This range may roughly be said to comprise waters with total solid contents up to 1000 parts per million, in cases where complete purification is to be secured, with an upper limit of about 1500 parts per million where partial purification is desired. The principal operating expense of the Electro-Osmose process is, as would be expected, the cost of the electrical energy required. With waters of relatively low initial concentrations (up to 300 or 400 parts per million), for example, the cost of the electrical energy is quite small compared to the energy required for thermal distillation. With increasing raw water concentrations, the expenditure of electrical energy is naturally greater, until, beyond the limits mentioned, the cost may be prohibitive.

The only other major item of expense with the Electro-Osmose is the rinse water for the electrode compartments. The volume of this wash water is equal roughly to that of the water being purified. Against this, in distillation, is the volume of cooling water required, which is several times that of the condensate—although the cost of the cooling water may be

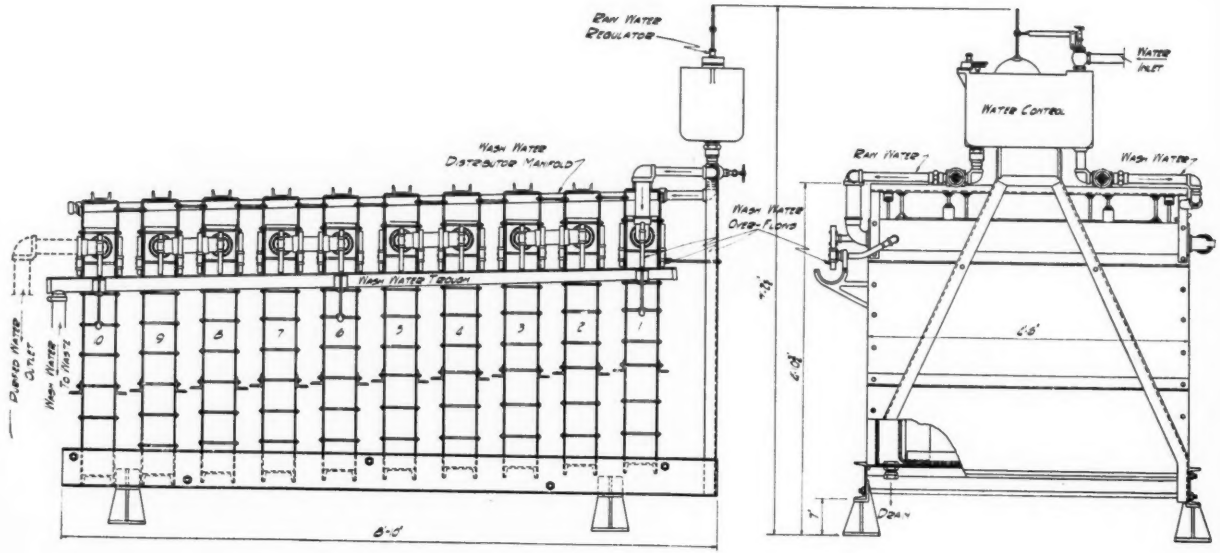
Rain Water Regulator
Water Inlet
Water Control
Wash Water Distributor Manifold
Rain Water
Wash Water
Wash Water Over-Flow
Wash Water Trough
Drain
6'-0"
4'-6"
4'-0"
1'
10
9
8
7
6
5
4
3
2
1

FIGURE 4

reduced considerably by recirculating systems employing such devices as cooling towers, spray ponds or other means for cooling the bulk of the water by the evaporation of a portion of it.

The only attention required for the Electro-Osmose apparatus is the periodic cleansing of the diaphragms. The necessity for this arises from the fact that when the calcium and magnesium ions are discharged in the cathode chamber, the products of electrolysis, together with the reaction products of these on the raw water, form a sediment, a small portion of which is deposited in the cathode diaphragm, gradually clogging it to an undesirable degree. The cleaning of the diaphragms consists in immersing them first in dilute hydrochloric acid and then in water. In practice, an extra set of diaphragms is supplied so that the change may be made quickly and the clogged diaphragms cleaned when convenient.

The necessity for cleaning the diaphragms is therefore dependent on the hardness of the raw water. With the average water, the diaphragms will have to be cleaned every two or three weeks.

## Pre-Treatment of the Water

Since the necessity for cleaning the diaphragms arises from the presence of calcium and magnesium compounds in the raw water, it follows that any softening process which will remove the calcium and magnesium will eliminate the necessity for the cleaning. Either the lime soda or zeolite softening process may be employed, though the use of one or the other may be preferable in different instances. In the case of a water containing large amounts of calcium and magnesium bicarbonates, treatment with lime, as has already been pointed out, will not only remove these diaphragm-clogging substances, but in doing so will reduce correspondingly the dissolved solid content of the water and so decrease the amount of electrical energy required in the subsequent Electro-Osmose treatment.

The zeolite softening process will eliminate the calcium and magnesium practically completely; but as this process simply replaces the calcium and magnesium with sodium, it is obvious that the amount of dissolved solids is not reduced in the water going to the Electro-Osmose apparatus.

The Electro-Osmose process is not a competitor of lime soda or zeolite water softening. Where the latter processes can be employed to advantage, they are almost always very much cheaper than the Electro-Osmose, both in the initial cost of the equipment and in the operating charges.

## Limitations of Electro-Osmose Purification

Since the Electro-Osmose functions primarily by electrolysis, it follows that the process will not remove substances which do not carry, or cannot be given, an electrical charge. Inert gases, typical non-electrolytes, and some colloids, particularly certain organic colloids, will therefore not be removed.

Fortunately, however, these impurities are usually present in normal waters to a negligible or unobjectionable amount, or, as in the case of inert gases, their removal for most technological purposes is unimportant.

### Field for the Electro-Osmose

Since water completely purified by the Electro-Osmose compares favorably with distilled water, it may be employed in practically all cases where distilled water is now being utilized. In Europe, many installations are reported to be furnishing "distilled water" for the manufacture of pharmaceuticals, for storage batteries, for the manufacture of mirrors, and in a variety of other uses. In the United States, the first large installation is just being made in the ice industry, where a water containing an excessive amount of dissolved salts is being treated to reduce this amount to a point where good ice can be made from the treated water. The type of Electro-Osmose equipment supplied for this purpose is shown in Figure 4. Arrangements have also been made for placing on the market a recently developed laboratory type of apparatus.

If the progress of the Electro-Osmose in Europe may be taken as a criterion, there is an interesting and promising future for the new process in this country.

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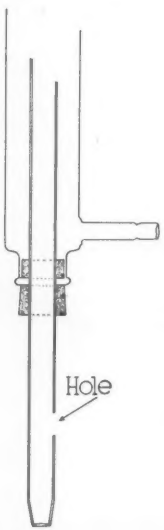
## AN IMPROVED REFLUX CONDENSER

L. A. PAPPENHAGEN, MOUNT UNION COLLEGE, ALLIANCE, OHIO




In the refluxing of systems containing ether, alcohol, or other volatile solvents, considerable danger is sometimes encountered by the fact that the condensed liquid in running down the condenser tube may shut off the passage of the rising vapor. As a result of the gas pressure formed in the system, the condensed liquid collects in the condenser tube and at times may spout out the tube at the top, pushed by the rising vapor. This liquid spouting out of the condenser becomes a serious fire hazard, particularly as it is often advantageous to leave a set-up refluxing when the operator is absent. This trouble may be completely overcome by blowing a small hole in the side of the inner tube of condenser about 2–3 cm. above the lower end.

This same type of trouble sometimes occurs in the condenser tube above the gas-generator flask of a carbon dioxide apparatus and may be remedied in the same manner.

# THE GENERAL ELECTRIC RESEARCH LABORATORY. WHAT IT IS AND WHAT IT HAS ACCOMPLISHED

Guy Bartlett, General Electric Company, Schenectady, New York

It would be difficult to name an industry that has been more closely associated with research than has the electrical industry; and in that industry the work of the General Electric research laboratory has played an important part. It was established 29 years ago, at which time E. W. Rice, Jr., then vice president and now honorary chairman of the board of directors, made the statement:

> Although our engineers have always been liberally supplied with every facility for the development of new and original designs and improvements of existing standards, it has been deemed wise during the past year to establish a laboratory to be devoted exclusively to original research. It is hoped by this means that many profitable fields may be discovered.

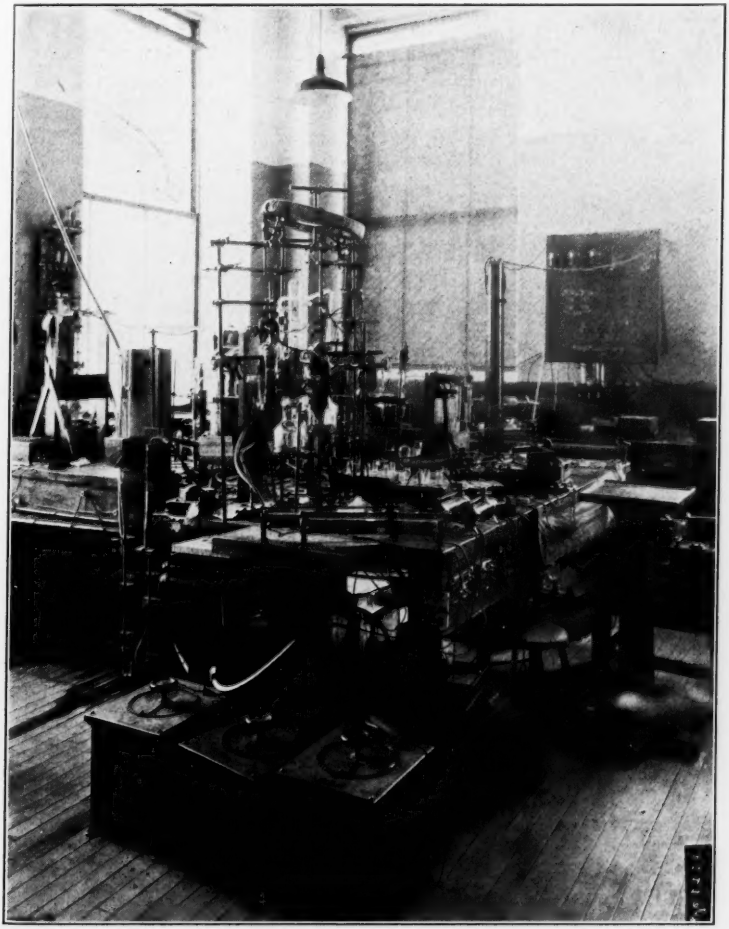
Back in 1901 Dr. Willis R. Whitney and his assistant, Thomas R. Dempster, wrestled for three days a week with some of the many unsolved problems of electricity, in the newly established Research Laboratory of the company. Twenty-eight years have elapsed. Dr. Whitney and Mr. Dempster are still in the Research Laboratory, but it is a much enlarged laboratory. Today it occupies the major part of two of the largest buildings in the front of the Schenectady Works, and the staff includes more than 400 physicists, chemists, electrical engineers and other scientists, with their assistants. Mr. Rice's hope—"that many profitable fields may be discovered"—has been more than amply realized. The inventions, the improvements, the new processes, and the new knowledge which have been unearthed and developed in the Research Laboratory have been of inestimable value, both to the company and to the public. New fields of application for electricity have been uncovered; the sum total of our knowledge of pure science has been decidedly increased; and, in the field of illumination alone, for instance, the savings to the American public have been a billion dollars a year for the current consumed by incandescent lamps—a result of the improved efficiency of the lamp, and a result of research.

What have been some of the outstanding achievements of the laboratory? Prominent among them have been the remarkable advances in incandescent lamps, including in succession the metallized carbon filament lamp, the ductile tungsten filament, and the gas-filled Mazda *C* lamp. There has been the magnetite electrode for arc lamps—the only survivor against the Mazda *C* lamp in street lighting—and there have been the Coolidge X-ray and cathode-ray tubes and apparatus developments; electron tubes of many types for radio and other work, the Tungar rectifier for battery charging, the Langmuir vacuum pump, the calorizing of steel, the invention

THE GENERAL ELECTRIC RESEARCH LABORATORIES

The inventions, the improvements, the new processes, and the new knowledge which have come from the Research Laboratory have been of inestimable value, both to the company and to the public.

of water japan, the self-lubricating Genelite bearing material, the sheath wire with mineral insulation for heating elements, the heat-resisting Calite alloy, atomic hydrogen welding, the improved tungsten carbide cutting



DR. LANGMUIR'S WORK TABLE
The Mazda *C* lamp, the high-vacuum power tube, the thoriated filament, and atomic hydrogen welding claim this table as their birthplace.

tool material—all these, and many more, must be included in any enumeration of the accomplishments of this one laboratory.

The development of such products has not been the only work of the

laboratory, however. Many investigations in pure research have been conducted, and the findings published in more than 400 articles in scientific and technical journals. Some of this pure science has been found immediately applicable; at other times the findings have been put to practical use only after considerable time has elapsed. Similarly, such investigations have often been found to affect unexpected fields, as when Dr. Langmuir's investigations of traces of gas in incandescent lamp bulbs led to the development of atomic hydrogen welding. Some of the laboratory products have been accidental, or incidental, results of investigations in pure science; others have been the result of persistent work toward a predetermined goal.

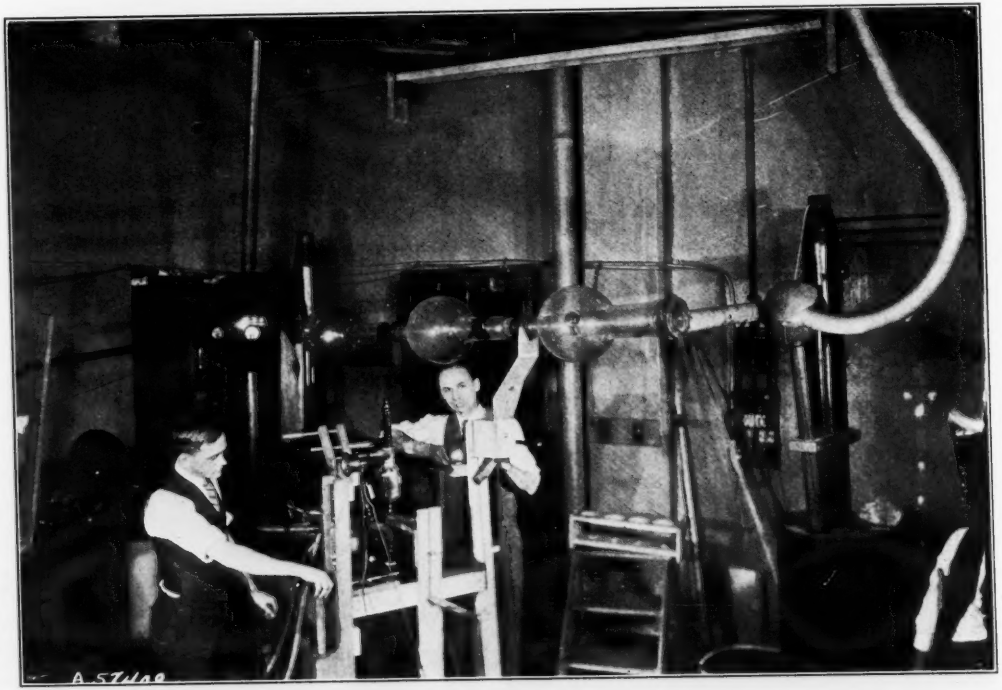
DR. WILLIS R. WHITNEY
Vice-President of the General Electric Company and director of the Research Laboratory.

Still another Research Laboratory activity has been the handling of specific problems affecting factory production, such as improvements of processes, location of troubles, or the development of new or better materials such as alloys and insulations. Possibly such a problem will be solved in a few hours—or many months, or even years, may be devoted to the subject.

A one-story, shed-like structure formerly occupied by the Standardizing Laboratory, was occupied by Dr. Whitney in 1901, but within a year more room was provided when the laboratory was moved to another building. There it remained until 1904, when Dr. Whitney and his three assistants moved to still more spacious quarters.

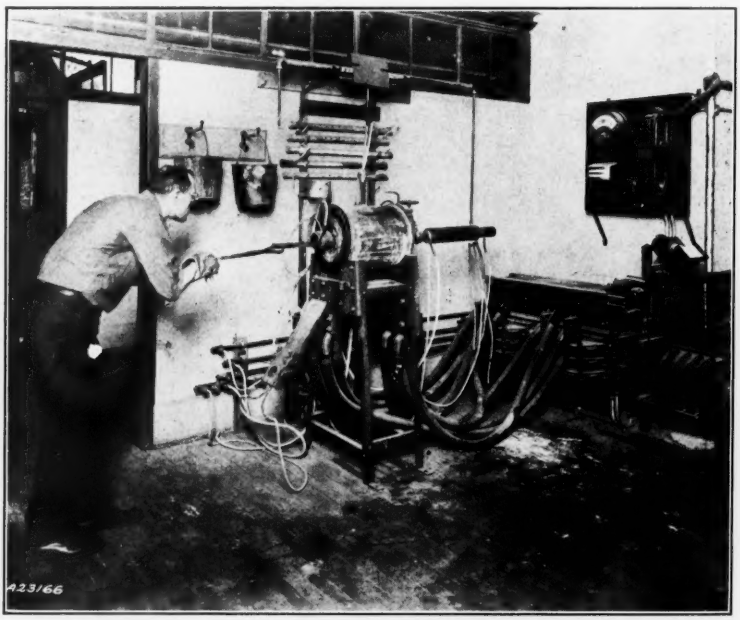
In 1912 the still further expanded laboratory moved into a seven-story building that was built expressly for it. And then, three years ago, when it was found necessary to expand the laboratory facilities even more, another six-story building was connected to it. Approximately 90,000 square feet of floor space in the first building, divided into 132 rooms, and an additional 52,000 square feet in the second building, divided into 63 rooms, are included in the present Research Laboratory quarters.

City water, river water, illuminating gas, compressed air, vacuum, high-



900,000-Volt Cathode-Ray Apparatus
Opening the way for additional penetration into the realm of the unknown.

pressure hydrogen, low-pressure hydrogen, oxygen, live steam, low-pressure steam, vacuum cleaning, and distilled water are available in each workroom. A maximum of 250 kilowatts can be drawn from one or two terminal switchboards in each room; or connections can be made to any other room or to the basement distribution board, and from there to other laboratories in the plant. Work requiring 20,000 amperes, or 200,000 volts, or temperatures as high as 3000°C. or as low as —200°C. are also to be had with standard equipment.



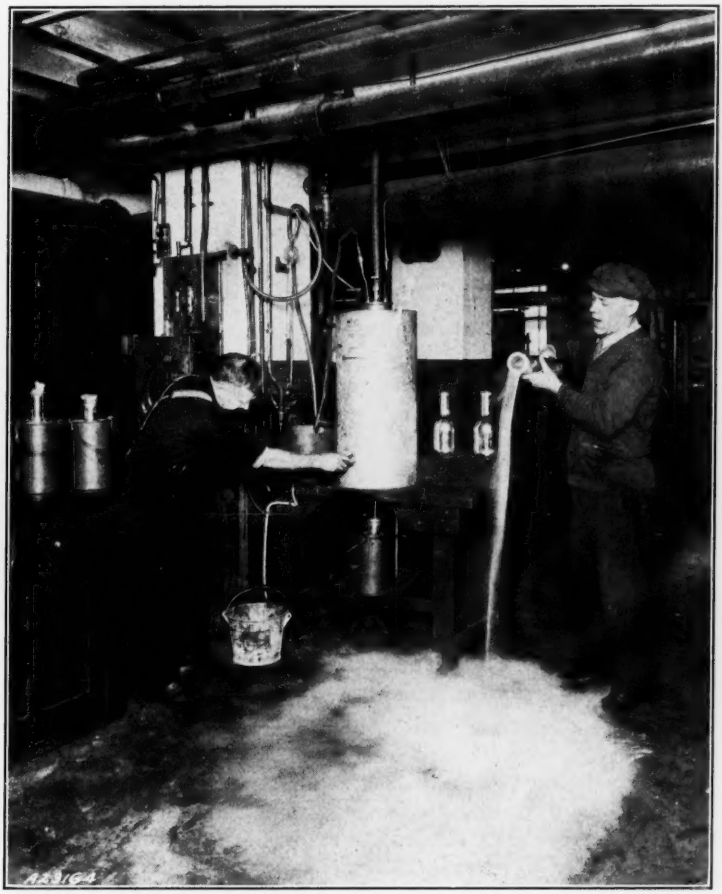

TEMPERATURES AS HIGH AS 3000°C. MAY BE OBTAINED WITH TYPE OF APPARATUS SHOWN

Horizontal ducts, of sufficient size so that workmen can easily make alterations or repairs, carry the pipes and wires above the corridors; and vertical ducts connect these to the basement of the first building. The wiring arrangements are such that each cable can be withdrawn and replaced without undue interference with the others.

The basement of the first building is used to provide facilities which are in general demand, such as electric power, vacuum, liquid air, motors, transformers, and rheostats. Power is distributed at 125–250 volts direct current, and 550–240–120 volts alternating current, from 154 trunk lines,

and by separate lines from 24 motor generators. Service valves for the distributing pipe lines also are in the basement.

The first floor of this building contains the main offices, the library of 3000 volumes and technical journals, and experimental rooms for X-ray



Temperatures as Low as —200°C. Are to Be Had with Standard Equipment

and cathode-ray investigations. Connected to the rear is a one-story section of 4000 square feet, used as a metal-working department. Its equipment includes rolling mills, 100-ton hydraulic presses, tungsten and molybdenum treating equipment, swaging machines, wire-drawing appara-

tus, high-temperature hydrogen furnaces, a ball mill, sifting apparatus, and vacuum furnaces. A tile roof of this section provides space for outdoor experiments.

A large portion of the second floor is used for model and apparatus construction, and contains a machine shop and carpenter shop. Lathes, millers, shapers, drill presses, disk grinders, surface grinders, external and internal grinders, precision lathes, and diamond-die drilling and polishing machines are included in the equipment of the machine shop. The carpenter shop is similarly well equipped with machines, but its chief function is to provide high-grade hand work on wood and similar materials. A transformer and coil department in another building supplies special apparatus not available in the factory.

For the benefit of visitors, a room in the front of the second floor has been fitted out with numerous equipments for demonstrating some of the interesting laboratory experiments and developments.

On the third floor there is the analytical laboratory. In other rooms on the same floor there are electric furnaces of different types, photomicrographic equipments, metal testing machines, and similar equipment for the study of ferrous and non-ferrous alloys. Development of atomic hydrogen welding is also being carried on there.

Studies of incandescent lamps occupy most of the fourth floor, along with the pure science investigations of Dr. Langmuir. Glassblowing rooms, photometers of different types, and lamp life-test racks are included in the incandescent lamp equipment.

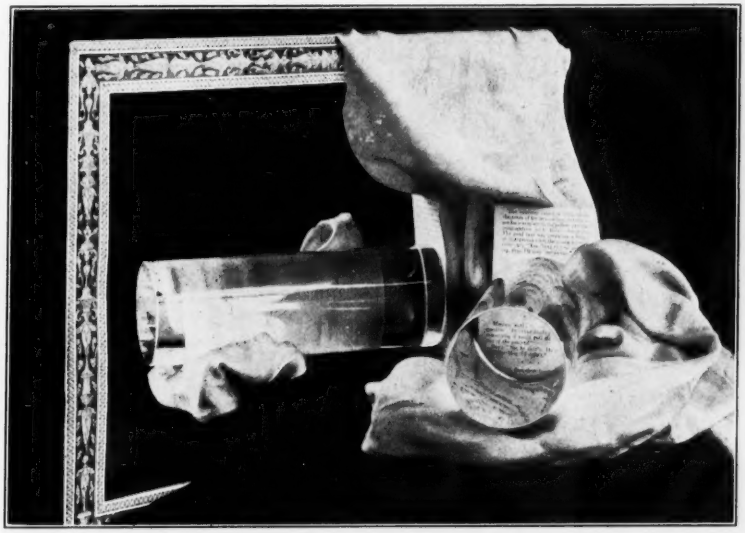
Apparatus for making X-ray spectra photographs to reveal the arrangement of atoms in metals and other crystalline matter, facilities for experimental work on electric refrigerators, and life-test racks and other testing equipment for radiotrons and other vacuum tubes are contained on the fifth floor. A large lecture room for the various meetings such as the weekly colloquia is also located there.

In the newer building most of the laboratory's three floors are devoted to investigations of vacuum tube and radio problems. Experiments with photoelectric tubes, hot cathode neon tubes, radio loud speakers, sound films, and radio tube and circuit investigations are conducted there. Still other lines of work to be found there are the development of new insulations and molded compounds, studies of vibrations and noise in electrical apparatus, and theoretical investigations along numerous lines.

Not all the work of the Research Laboratory is carried on within these two buildings, however. Various types of electric furnaces up to two-tons' capacity, housed in another building, are used for the production of all the high-speed steel used in the Schenectady plant. Titanium carbide for magnetite arc electrodes, boron carbide for use as a deoxidizing flux in casting copper, heat-resisting alloys, and non-magnetic alloys are still

other materials produced in electric furnaces under the supervision of the laboratory. The graphitizing of carbon brushes, calorizing of steel, purification and reduction of tungsten and molybdenum are other processes that are or have been followed by the laboratory. Mazda Service, still another part of the laboratory, maintains supervision over lamp production and tests.

The Research Laboratory is but one of several General Electric laboratories, however. In Schenectady there also are the General Engineering laboratory, devoted to general and special engineering problems, including



Clear Fused Quartz

At the Thomson Research Laboratory, Lynn, was developed the method for producing this superior glass-like substance in large masses.

high-voltage phenomena, the development and standardization of instruments and test methods, and the development of new apparatus like the photophone and the improved cathode-ray oscillograph; the Testing Laboratory, for investigating the physical and chemical properties of materials; and the Illuminating Engineering Laboratory.

At Lynn there is the Thomson Research Laboratory, where clear fused quartz and the supercharger for airplanes and automobiles, among other things, were developed; at Pittsfield there is the High Voltage Laboratory where artificial lightning of millions of volts is the toy of electrical engineers; and at both Lynn and Pittsfield there are additional laboratories

MILLIONS OF VOLTS STRIKE A MINIATURE VILLAGE
In the High Voltage Laboratory at Pittsfield artificial lightning of millions of volts is the toy of electrical engineers.

concerned with the production problems of those plants. Then there are the lamp development and illuminating engineering laboratories at Cleveland, specializing in incandescent lamps and illumination.

What research has meant in the case of the General Electric Company is shown by a glance at the products of the Schenectady works, just one of the company's plants. Two-fifths of the production there last year was in apparatus developed since the World War—apparatus not manufactured by the company a decade ago. Chief among these, of course, were radio and electric refrigerating apparatus.

A quarter of a century ago the industrial experimental laboratory was itself an experiment. Today it occupies a firmly established and most important position in accelerating the progress of American industry.

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## A POSSIBLE SOURCE OF ERROR IN RAPID WEIGHING

M. B. GEIGER, GEORGETOWN COLLEGE, GEORGETOWN, KENTUCKY

Static electricity may be a nuisance in the chemical laboratory as well as to radio fans. In this laboratory appreciable errors in weighing have been noted which may be accounted for by static electrical effects.

In rapid weighing, when using a watch glass on the balance pan, the watch glass is dried between weighings by rubbing with a dry towel. This gives rise to a static electrical charge which may be a source of error, especially if a metal spatula is used for transferring the solid being weighed, and this spatula is not removed from the immediate vicinity of the watch glass when making a weighing. We have observed as much as nine milligrams difference in the weight of the object when the spatula is directly above the watch glass and when it is removed. Of course, this error is not created if the spatula is removed before a final balance is made.

This static charge also proves to be a nuisance when weighing fluffy solids, as they are repelled from the watch glass and from each other much as pith balls repel each other when charged alike.

Both of these disadvantages may be avoided by first grounding the surface of the watch glass by touching various points on the rim with the metal spatula before the solid being weighed is placed on the watch glass. These static effects are most pronounced on dry, cold days and especially if the balances are located in a dry, cool place as they are at this institution.

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**Chinese Tung Oil Exports.** A cable dated May 4th, from U. S. A. Consul General F. P. Lockhart, Hankow, reports the total April tung oil exports from Hankow as 7,694,160 lb., of which 6,722,000 lb. were shipped to the United States and 972,160 lb. to Europe. Stocks of oil at Hankow at the end of the month were estimated at approximately 3500 short tons.—*Chem. Age*, **20**, 554 (June 8, 1929).

# MARKETING AMERICAN CHEMICALS. MERCHANDISING METHODS THAT HAVE ADVANCED A RELATIVELY NEW INDUSTRY TO A DOMINANT POSITION IN THE DOMESTIC AND WORLD MARKETS*

C. C. CONCANNON, CHEMICAL DIVISION, DEPT. OF COMMERCE, WASHINGTON, D. C.

Since 1922 when business generally was at low ebb in the United States, the American chemical industry has advanced to a position of importance and is today enjoying a period of prosperity. The International Economic Conference of the League of Nations is authority for the statement that the United States is the largest single factor in the world's chemical industries—accounting for approximately one-half of the world's five billion dollar output of chemicals and claiming an increasingly large share in the billion dollars worth of chemicals that annually enter into foreign trade. In contrast with the community marketing methods of the cartel system, the American chemical industry has reached its present position through an individualism that is the direct antithesis of the European conception. To point out the underlying basis of these merchandising methods and their close relation to the activities of the U. S. Department of Commerce is the purpose of the present discussion.

Though many activities of the federal government are of a regulatory character, fortunately this cannot be said of the work of the Chemical Division of the Department of Commerce, which is concerned solely with efforts designed to promote our trade at home and abroad.

In this present industrial age commerce vitalizes the march of progress so that there is no phase or feature of the ordinary life of each and every one of us which is not in some way inextricably and intimately associated with what may be referred to as business, and of all the great executive branches of the United States government no one is more closely associated with business than is the Department of Commerce.

The ambition of the American business man and the relationship of the Department of Commerce to him are aptly summed up in the following words of Dr. Julius Klein, Assistant Secretary of Commerce:

> The United States has set its face definitely toward the goal of business individualism, supplemented by associated and coöperative effort, which, in turn, is supplemented by government assistance.

"To measure is to economize." It was Lord Kelvin who said that our knowledge of any subject lacks scientific thoroughness if it cannot be expressed numerically. Production, thanks to scientific research and prudent business management, has been placed on such a quantitative

* An address presented at the Convention of the International Advertising Association held at Berlin, Germany, August 12–15, 1929.

basis in the United States. The less tangible field of distribution has only recently responded to the same influences, but it is apparent that the rewards in this direction are even more attractive.

American chemical manufacturers, as in other lines of industry, have come to realize that the older selling methods must be replaced by carefully studied marketing policies and plans, directed along productive channels and supported by adequate sales promotion. Underlying all of this procedure is the necessity for exact knowledge—first of products, then of markets, buying habits and types of buyers, distribution methods and sales organization.

President Hoover aptly summed up and expressed the situation in these words:

> To create a sense of need abroad for our particular goods—to induce the purchase of them—is a science in itself.

Chemicals are seldom sold directly to the public. Rather they are industrial raw materials made by one industry and consumed by another in the manufacture of a product in which the identity of the original chemical may be lost entirely. It is this relation that puts the merchandising of chemicals squarely into the field of industrial marketing where there are certain principles that are common to the solving of practically all merchandising problems. These principles are four in number. First, there must be the determination of the market and its analysis on the basis of potential volume and profit. Second, the buying influences must be studied to ascertain which men control purchasing of the product and how it is bought. Third, there must be the sales organization and the machinery for approaching the market efficiently and economically. Fourth, and finally, there must be developed the selling appeals and sales promotion that relate the product directly to the self-interest of the buyer.

Doubtless there are almost as many ways of applying these principles as there are industries that make use of them. Many American manufacturers, including a number in chemical industry and a great many more in the field that supplies chemical engineering equipment and accessories, have found it convenient to develop their marketing policies and plans in the form of ten simple steps. No particular novelty is claimed for this procedure but since it is, in a way, typical of American marketing methods in general, I should like to have you consider this succession of steps in their relation to the chemical industry.

### 1. Markets

Reduced to its elements, this first step is merely the cutting of the goods to fit the cloth. In other words, the manufacturer analyzes the logical markets for his products and then rates them according to their size,

importance, and the potential returns from each industry. The chemical manufacturer begins his study with an analysis of his present sales by products in order to get a clearer idea of the relative demand for his output. Then follows an analysis of product sales with reference to the margin of profit in each in order to make certain that sales effort on each product is not out of proportion with the returns. Profits are sometimes sacrificed for volume without the manufacturer realizing the futility of that effort. But once the products are selected that promise the greater return, there must be still another sales analysis to determine the industries in which these can be sold most profitably. Too often a manufacturer finds that he has been wasting time and effort in selling to industries where the potential prospect is not sufficiently large to repay him for the development. In other cases selling costs may be prohibitive due to inaccessible markets, uneconomic buying practices or special sales resistance.

So far the manufacturer has been studying his past limitations as revealed by his own sales records. To measure his future prospects he must make use of an outside yardstick and for this purpose he probably uses the figures of the U. S. Department of Commerce or the current statistics compiled by the trade associations, technical periodicals, and various business bureaus. Fortunately in recent years the biennial statistics of the Census of Manufactures have been available in sufficient detail to enable the manufacturer to break down the basic industry figures in order to show the size of establishments, number of employees, or the number of motors and horsepower employed in manufacturing. These detailed figures are extremely helpful in rating the market in relation to the number of worthwhile prospects. Take, for example, the paint and varnish industry which is a potentially important market for industrial alcohol. The census figures show a total of 923 establishments with a total value of products of $470,736,264, but 276 of these establishments have an output of less than $100,000 and account for but 3.2 per cent of the total value of products. In the next class of census figures (output $100.00 to $500,000) we find 320 more establishments which account for 16.5 per cent of the total value of production. The remaining group of 227 plants, each having an output of over $500,000, accounts for 79.6 per cent of the total. Here then is where our alcohol manufacturer would concentrate his effort to obtain his maximum volume of sales. The census production figures therefore offer qualitative as well as quantitative measure of the opportunities for sales development.

At present we lack comparable statistics on the disposition of commodities once they have been produced. This condition may shortly be remedied, however, for the last Congress authorized an entirely new departure in governmental statistical activity—the taking of a Census of Distribution. Referring to this important innovation in a recent address

before the Merchants Association of New York, Secretary of Commerce Robert P. Lamont said:

> One of the reasons we have not made more progress in increasing the efficiency of distribution is the fact that we have relatively little comprehensive information about the movement of commodities. It is believed by many students of business that more adequate information on the movement and marketing of commodities will enable business men to reduce the costs of operation very materially. It is believed that this new census will form the basis for a more thorough study of distribution and that as a result of these fundamental and basic figures it will be possible for trade associations and other organizations to compile much supplementary material which can be interpreted in the light of the comprehensive census statistics.

Certainly the chemical industry stands ready to gain materially from any study of its distribution activities.

That the advertising profession of the United States also recognizes the tremendous importance of this census of distribution is clearly shown by the following resolution which was adopted on May 16, 1929, at Chicago, Illinois, at the time of the annual business meeting of the International Advertising Association:

> *Whereas*, The International Advertising Association regards the proposed Census of Distribution as the most valuable single contribution to adequate basic statistical information necessary for intelligent evaluation of markets and the resultant elimination of wastes in distribution, be it
>
> *Resolved*, That the Congress of the United States be urged to pass the necessary enabling legislation authorizing said Census of Distribution and to appropriate adequate funds for its completion and further be it
>
> *Resolved*, That Congress be urged to take this action at the earliest possible moment in order that the maximum possible time, already limited, be given the Bureau of the Census for preparatory work.

## 2. Types of Buyers

Having set up the markets on which the chemical manufacturer is to concentrate his sales efforts, he turns to the study of the buying influences on the products he has to sell. He can well ask himself such questions as the following: Who in each plant of my customers is directly charged with the responsibility for the processes in which my products are used? Whom do my salesmen have to convince of the quality of my products? From whom does the order come? Who originates it? Who specifies the brand or manufacturer? Is buying done by individuals or by groups? If the latter, which men and how many men by title and responsibility must I reach with my sales story? How can I reach these men most effectively?

If in answering these questions the manufacturer is willing to go behind the scenes and seek out the real buyers by actual operating responsibilities rather than by titles, he will greatly have simplified his marketing problems.

It has been said many times that the chemical industry is its own best customer. The explanation for this statement is found in the unique degree to which the chemical industry is self-contained. The finished product of one branch of the industry often becomes the raw material for another. Thus the tar distiller produces a distillate that is refined by a chemical manufacturer and sold as a coal-tar intermediate to other manufacturers for the production of dyes, explosives, rubber accelerators, plastics, or photographic chemicals. The fertilizer manufacturer makes sulfuric acid, sells it to the coke plant for making ammonium sulfate, which is returned to the fertilizer plant for use as an ingredient in mixed fertilizer.

From the marketing viewpoint this close interrelation means that the chemical manufacturer must address his sales story to the same type of man who in his own plant is responsible for production. Thus maker and user speak the same language and are guided by the same knowledge of quality, properties, and behavior. This proves of mutual value in the drawing of specifications and the framing of chemical contracts.

### 3. Prospect List

Building and maintaining a list of men who control buying in each industry is the next step in marketing. After the type of buyer has been determined, the compilation of the list becomes a matter of recording names obtained from reports of salesmen, trade directories associations, and society membership lists. Prospect lists age rapidly and to be of value must receive continuous attention.

### 4. Sales Organization

At one time chemicals in the United States were sold almost entirely through middlemen known as brokers or sales agents. Government regulation, quota allotments, and other conditions of the war period brought the manufacturer for the first time into close relationship with his customers. Since then practically the whole American chemical industry has gone over to direct selling. The manufacturers have had to build competent sales organizations to supply the service needs of the consuming industries. In selling technical products such as chemicals, specialized knowledge of the buyer's problems is an absolute necessity. Thus sales engineers and technically trained service men are required to supplement and round out the work of the sales organizations.

### 5. Territorial Plan

After the manufacturer has selected the markets on which he is to concentrate his selling effort, his territorial plan consists merely in setting up his sales organization in strategic locations to serve these markets most

economically. The necessity for warehousing facilities and other arrangements for prompt and efficient shipping will also have a relation to the setting up of the sales territories. Many chemical manufacturers concerned with national distribution have found that the eight geographic zones corresponding to the principal freight rate territories of the Interstate Commerce Commission offer convenient units in which to break down their territorial problems. The following table based on the data of the United States Census of Manufactures for 1925 shows the relative importance of these eight zones for certain of the principal chemical consuming industries.

GEOGRAPHIC DISTRIBUTION OF CERTAIN AMERICAN CHEMICAL CONSUMING INDUSTRIES*

(Percentage of Total Value of Product 1925)

| | New England | Middle Atlantic | East N. Central | West N. Central | S. Atlantic E. S. Central | West S. Central | Mountain | Pacific |
|---|---|---|---|---|---|---|---|---|
| Textile dyeing and finishing | 47.0 | 41.2 | 2.2 | 3.9 | 3.8 | .. | ... | 0.9 |
| Cotton mfg | 36.0 | 13.8 | 0.8 | .. | 45.0 | 1.3 | ... | 0.5 |
| Chemicals | 0.6 | 57.4 | 26.4 | 4.4 | 3.0 | 0.6 | 0.5 | 3.0 |
| Petroleum refining | 1.5 | 23.1 | 6.8 | 4.3 | 0.5 | 35.7 | 3.7 | 15.6 |
| Paints and varnishes | 2.7 | 42.0 | 36.9 | 8.9 | 2.5 | 0.6 | 0.6 | 5.1 |
| Soap | 10.9 | 36.1 | 28.8 | 17.8 | .. | .. | ... | 5.7 |
| Paper and pulp | 25.8 | 25.7 | 23.2 | 12.3 | 0.4 | 1.0 | ... | 3.9 |
| Glass | .. | 58.0 | 29.7 | .. | .. | 1.9 | ... | 2.4 |
| Explosives | .. | 44.9 | 9.9 | 13.1 | 12.9 | 1.0 | 7.7 | 8.6 |

* *Chemical and Metallurgical Engineering*, **36**, 10 (Jan., 1929).

### 6. Personnel

This step ties in so closely with step four (nature of sales organization) that I need only emphasize the increasing importance of having men on the "firing line" with suitable background of selling experience, supplemented and supported by technically trained specialists in research and engineering who can, if necessary, supply the buyer with the how, why, and wherefore in the application of the products within the customer's own plant.

**7. Publication Advertising**
**8. Manufacturers' Literature**
**9. Special Promotion**
**10. Sales Keynote**

So far in my discussion of these theoretical steps which the progressive chemical manufacturer must follow in setting up his marketing machinery, I have confined myself to market analysis, plans, policies, and statistics, with all of which the Department of Commerce is in close touch because of its relation to industry. The remaining steps have to do primarily with sales promotion—a field in which my audience is more at home than am I. To complete my picture, however, I would remind you briefly that in the

chemical field we have the engineering type of publication read by the men responsible for production, the research and scientific journals that serve the laboratory and research departments, and the trade and market papers that carry the news and current price changes of the industry. In addition, in the allied and consuming industries such as textiles, petroleum, paint and varnish, and paper, there are many excellent industry publications that serve all interests within their more limited fields. Under the heading of "manufacturers' literature" comes the usual range of catalogs, engineering handbooks, and direct mail literature. Chemicals, *per se*, are not products that lend themselves to dramatic and spectacular advertising. Rather the manufacturer often finds it desirable to prepare and distribute highly technical data and reports on the properties and qualities of his materials, supplemented by flow sheets and working diagrams to educate the prospective customer in the profitable use of these chemicals within his own plant. Much of the manufacturers' literature in the chemical field is of this character.

Special promotion as it is interpreted here refers to the use of exhibits at the biennial and other expositions of chemical industries, the preparation of papers for conventions of engineering and scientific societies, talks at trade association meetings, sales conventions, etc. Chemical industries in the United States, because of a secretiveness inherited from earlier days, have done less along these special lines of promotion than have the equipment and accessory manufacturers within the same field. It is evident, however, that as the industry grows it must make greater use of all modern tools of sales promotion.

The last step in our marketing program and one which can conceivably be the most important is the development of the proper sales appeals. It is fundamental that these must tie the product directly to the self-interest of the buyer. Fear of loss or hope of gain will always have a determining influence in chemical buying and the American manufacturers who have marketed their products most successfully have always driven home the ideas of improved operation, increased production, and lower costs which result from better quality, performance, and technical service.

It was my original intention to conclude this discussion with some definite examples of outstanding marketing successes in the American chemical industry. Perhaps the same purpose can be accomplished as well by briefly calling to your mind the relation between certain names and ideas that have been developed as the result of constructive advertising: Bakelite, the material of a thousand uses; du Pont, chemical engineering research and service; J. T. Baker, analyzed chemicals; General Chemical's shield of standard purity; U. S. Industrial Alcohol's nation-wide service and delivery; Amersol, quality control; Texas Gulf Sulfur, $99^1/_2$ per cent pure; Carbide and Carbon, scientific progress; Hercules Naval Stores,

developing a new industry; R & H, specialized service to specialized industries.

If we could evaluate all of the factors that have contributed to the remarkable growth of the American chemical industry within the past six or seven years, I think we would find that the dissemination of knowledge regarding new products and processes, foreign trade and market developments, production and distribution, underlies all of our industrial progress. And among these important factors is advertising which has a great influence on the marketing of American chemicals.

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## ORGANIC SYNTHESES

The Board of Editors of "*Organic Syntheses*" (an annual publication of satisfactory methods for the preparation of organic chemicals) has decided to collect, revise, and rearrange the preparations in the first nine volumes in such a way as to make them more suitable for general use in synthetic organic chemistry. All of these preparations are to be published in a single comprehensive volume to be designated as the "Collective Volume—Revision of Volumes I–IX."

In this work of revision, suggestions in the way of corrections, difficulties in checking, new and improved methods, etc., would be greatly appreciated.

*Address:* HENRY GILMAN, Iowa State College, Ames, Iowa, U. S. A.

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**Ether Denounced as Dangerous.** Ether has been denounced by the dean of the University of Michigan medical school as "the most dangerous anesthetic in modern surgery."

Dr. Hugh Cabot, widely known as a surgeon and author and dean of the medical school at Ann Arbor since 1921, let it be known that in his opinion "if it were possible to trace casualties to the use of ether in the operating room, it would have been found to have killed more people than any of the other three anesthetics used: chloroform, nitrous oxide or ethylene."

Dr. Cabot continued his challenge of the use of ether by stating that in the past, less than ten per cent of the deaths which could be traced to the administration of that anesthetic were ever published.

The mortality in ether deaths, except in a very few cases, does not come immediately after its administration, he said, as is seen in the cases of patients exhibiting a fatal contra-indication for chloroform. In a few days, however, complications seem to develop, and death is said to be due to "cardiac failure, bronchial pneumonia, or some other pulmonary complication that satisfies the surgeon," he went on.

Dr. Cabot declared that the explosions which have attended the use of ethylene gas have been due to "careless methods manifested in its administration."—*Science Service*

# INCREASING THE USEFULNESS OF THE SHORT FOCUS PROJECTION LANTERN. PART I

ROBERT TAFT, UNIVERSITY OF KANSAS, LAWRENCE, KANSAS

A projection lantern with a short focus lens (in the neighborhood of 4") has several desirable features for presenting data and diagrams to the smaller classes of advanced students in chemistry.[1] The writer has been experimenting for the past several years with various arrangements of lantern and screen and of various screen materials, seeking to obtain the most satisfactory combination for the purpose noted above. As there is but little published information of this nature available, it has been thought worthwhile to publish these notes. Doubtless other teachers could make valuable suggestions from their experiences.

The more important requirements of a lantern of this type are:

1. The lantern must be capable of giving sufficient illumination to render the image plainly visible in moderate daylight. One of the objections to the lantern as ordinarily used for lecture purposes is that nearly complete darkness is necessary. In the ordinary teaching period, the opening and closing of shades or turning lights on or off consumes time at the expense of instruction. It is possible by using a short focus lens with sufficient illumination to avoid this difficulty.

2. The lantern and screen should be so placed that (*a*) it neither obstructs the student's view of the blackboard or apparatus used in the course of ordinary instruction, (*b*) the lantern can be easily and conveniently operated by the instructor. The screen should also be within the instructor's easy reach. Ease of operation is secured by the use of a short focus lantern, as it does not require the assistance of the lantern operator.

3. The screen should be opaque to avoid undue loss of light; should be light in color; and should be capable of taking chalk which can in turn be readily removed. This last point the writer considers to be one of the most important advantages of this method of instruction. The teacher of the less elementary branches of chemistry is not generally interested in the reproduction of pictorial scenes but of data in tabular form or in graphic form. If it is desired to emphasize some special data or to sketch in some alternative course for a pair of variables, etc., this can be done by marking with chalk when the image is on the screen.

A number of arrangements have been tried out, some to a greater extent than others. They are all given as possibly some one of these methods would be better suited to given local conditions than the one

[1] The writer has found that it saves considerable time for both instructor and students in the instruction period if the more important illustrative material for a course concerned with the examination of data is available as lantern slides. For example, in the course of several years, over a hundred slides have been collected of data illustrating the more important facts and laws dealt with in elementary physical chemistry. The writer believes that the time and expense connected with this collection has been well spent. With the advent of small "still" moving picture projectographs it might be feasible to copy data and diagrams on several cartridges. Much smaller storage space would be required than for lantern slides, but a greater projection distance would be required than for the short focus projection lantern described in this paper.

which the writer considers to best fit his needs. The equipment in each case was a Model *B* Bausch & Lomb Baloptican, fitted with a 4″ lens, the illuminator being a 500-watt lamp.

The experiments were carried out in a lecture room 21′ × 28′ and having 6 rows of seats of 9 each. Outside light came from three windows on the south side of the room. The room arrangement is shown in Figure 1.

Some of the possible arrangements of the lantern and screen are shown in the various subfigures of Figure 2. The arrangement shown in Figure 2*a* was as follows:

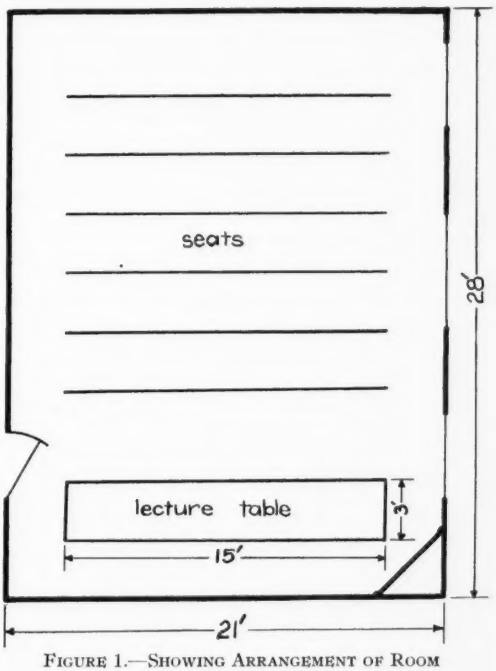


FIGURE 1.—SHOWING ARRANGEMENT OF ROOM AND LIGHTING

A section of the lecture table top, some 30 inches wide was removed from the center of the table. The portion removed was then hinged to the rear edge of the table, *i. e.*, it could be used as a cover on a box. The lantern was then secured to the bottom of this piece by bolting the back legs and the front posts to it. By returning the movable piece to its original position the lantern could be stored inside the desk when not in use. It was found necessary in order to secure sufficient rigidity to fasten the lantern table to the back wall by a hook when in use. The screen was a Translux screen which could be mounted on the outer edge of the opening in the lecture table by a small length of gas pipe. The screen likewise could be stored in the opening in the desk when not in use. The bellows of the lantern as thus used was not adjustable and care was necessary in mounting the lantern that the bellows extension was sufficient to bring the image into approximate focus on the screen.

While this arrangement has some desirable features, *i. e.*, easily operated by the instructor and conveniently stored, it has several defects from the standpoint of the requirements tabulated previously. The instructor

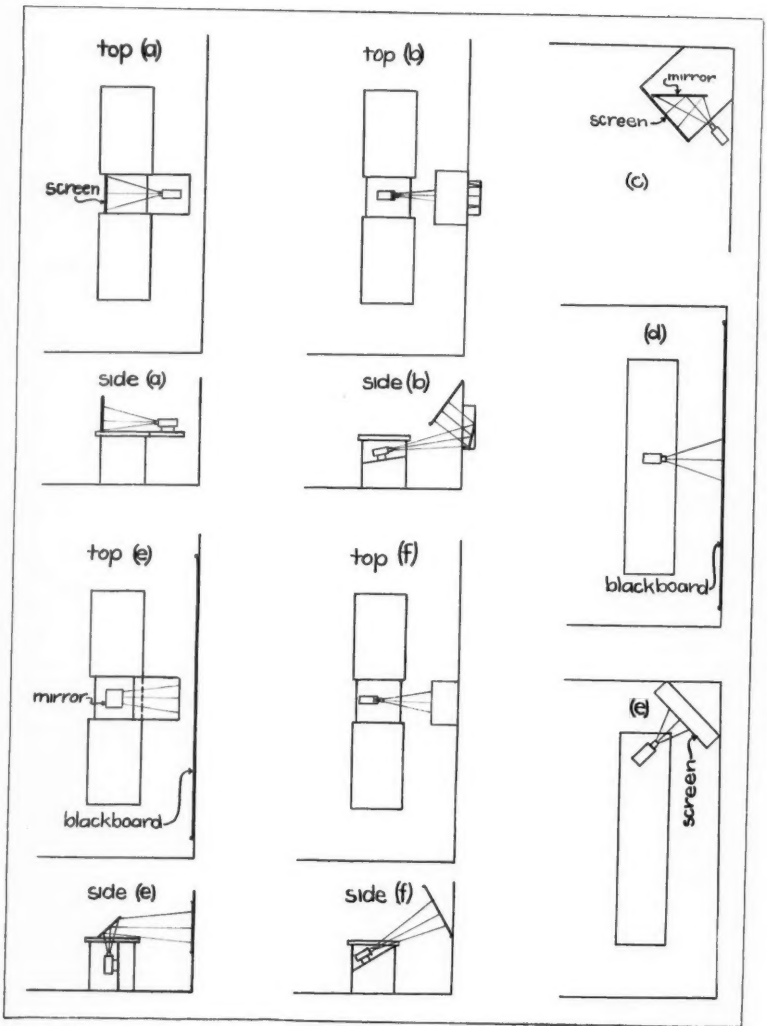


FIGURE 2.—SHOWING SOME OF THE POSSIBLE ARRANGEMENTS OF THE LANTERN AND SCREENS

must walk around the lecture table to be in front of the screen; the screen cuts off a considerable view of the blackboard; and lastly a transparent screen itself presents several objections. One cannot write with chalk on such a screen and further, the illumination is not altogether satisfactory. Depending upon the position of the observer, a portion of the screen is much more intensely lighted than the remainder, so that in order to see the image the observer must shift his position from time to time.

It should be observed that the arrangement would be somewhat more satisfactory if the screen and lantern had been mounted at the end of the lecture table rather than in the middle.

Two other arrangements for using transparent screens are shown in Figures 2*b* and 2*c*. The arrangement in Figure 2*b* can only be used when space behind the wall is available. An opening is cut in the wall, the lantern directed against the wall, and a mirror is placed as indicated. The image then is reflected through the opening onto the Translux screen. The proper angle for mounting the mirror depends upon the angle which the optical axis of the lantern makes with the vertical and this in turn will depend upon how high the screen is placed. It is not a difficult matter to adjust these by trial and error. Only good quality mirrors should be used. The size of the mirror will depend upon how near it is placed to the lantern; the closer to the lantern the smaller the mirror required.

The arrangement shown in Figure 2*c* is used by Prof. R. C. Moore, Department of Geology, the University of Kansas. It is particularly adapted for showing pictorial scenes in daylight, the instructor being his own operator. A cabinet is built as diagrammed, which is blackened on the interior. A Translux screen is placed in front of the cabinet. The optical axis of the lantern is placed parallel to the screen and the mirror at an angle of 45° to the screen. In the device as used, the mirror is 30 × 40 inches and the screen 48 × 60 inches, although this could be somewhat smaller. A small hole is cut, as indicated in the diagram, to allow the projecting beam to strike the mirror. The lantern is placed on a cabinet which serves as the lantern slide file.

A self-contained portable unit, somewhat similar in arrangement, has been designed by Dr. T. T. Quirke of the University of Illinois and has been placed on the market.[2]

None of these arrangements, however, is satisfactory if one wishes to write or draw on the screen upon which the image is present. This requires an opaque screen capable of taking chalk, which can be easily removed. The arrangement shown in Figure 2*d* to 2*f* has been used with this purpose in mind.

That shown in Figure 2*d* represents the simplest arrangement. The lantern is best placed at one end of the lecture table (the darkest end is, of

[2] The Projectograph Company, Station *A*, Champaign, Ill.

course, best) and the image thrown directly on the blackboard. The front of the lantern must be elevated in order to get the image high enough. Due to the fact that the upper rays must travel farther than the lower ones, distortion of the image is produced. If the image is not made too large, this distortion does not greatly interfere. In the absence of any better arrangement, the projection of data and diagrams will be found workable. If it is desired to use this method permanently, a somewhat better arrangement is shown in Figure 2*e*. The lantern is placed at a slight angle from the vertical, within the desk, and the top of the desk, removed and made removable. A mirror *ab* is placed to reflect the image upon the board.

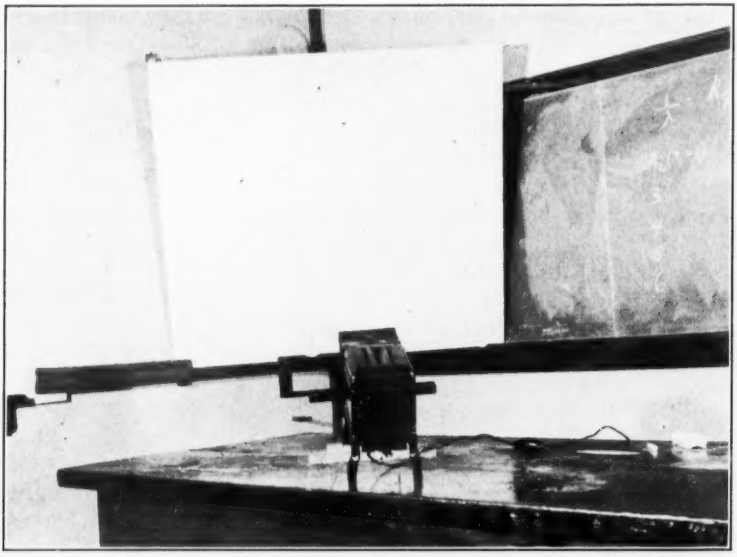

FIGURE 3.—SHOWING ARRANGEMENT USED BY THE AUTHOR

The mirror should be placed at an angle of 45° with the optic axis of the instrument. It will be found that if the lantern is exactly vertical some distortion is still produced. This can be almost eliminated by placing the lantern at a slight angle to the vertical. The opening in the desk must be of sufficient dimension to permit the instructor to easily operate the lantern.

The objections to this method are that the lantern is in a somewhat awkward position and more satisfactory screen materials are available than the blackboard.

The arrangement shown in Figure 2*f* has been tried. The lantern is

mounted within the desk at the angle shown and the image projected on the screen described below which is hung so that it is at right angles to the optic axis of the lantern. This method, while again workable, is open to the objections that the lantern is not placed so that it can be most easily operated and the screen is not in the most convenient position for the instructor.

The arrangement shown diagrammatically in Figure 2*e* and photographically in Figure 3 has been found most satisfactory for the writer's purpose. The lantern is mounted permanently at the rear by bolting the rear legs to brackets screwed to the table. The front of the lantern is elevated[3] so that the image is raised to the desired height. The screen is placed so that it is at right angles to the optic axis of the lantern and at the same height as the blackboard; the position being found by trial. When the correct position is found, its position is measured and brackets of strap iron made to secure it in this position.

The screen was made by taking a cheap grade of blackboard (not slate but made of pasteboard or composition board) and mounting it in a light wooden frame, the dimensions of the screen being $3 \times 4$ feet. The face of the screen was painted with several coats of white paint[4] mixed with approximately an equal volume of ground pumice; the object of the pumice being to secure a matte and gritty surface.

It was found with this screen and an image $3' \times 3'$ that illumination was sufficient to render it visible at any point in the lecture room without darkening the room. In a room in which outside light fell directly on this screen, it would be necessary to shut off this light; a point to be remembered in choosing a location for the screen. As white chalk would not be visible on this screen, colored chalk was used. The writer prefers blue chalk to other colors as it shows up somewhat better than do other colors and is removed more readily. After some use, it is necessary to clean the screen with a dampened cloth. In the arrangement as used, the lens is approximately 60 inches from the screen.

It should be remarked that these various arrangements require different methods for inserting the slides in the lantern. A little practice will soon accustom the instructor as to the proper method for a given arrangement.

[3] Greater elevation than that furnished by the adjustable legs has been found necessary.

[4] Any chemist should know better than to use a lead paint.

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**X-Ray Detects Smuggled Diamonds.** To locate diamonds swallowed or concealed beneath the skin of those attempting to smuggle them out of the Union of South Africa, government authorities at Port Nolloth are installing an X-ray machine with which suspects can be searched.—*Science Service*

# FRESHMAN CHEMISTRY IN AMERICA IN 1822

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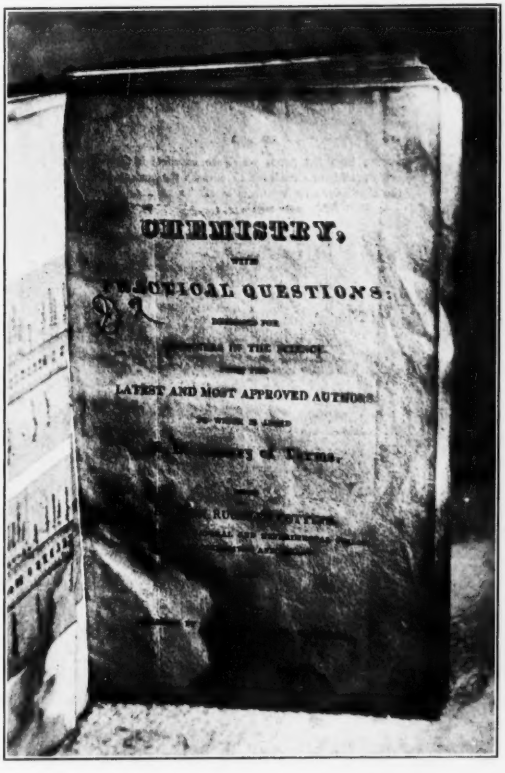
By the year 1822 chemistry may be said to have been fairly well established and was taking on modern tendencies. Boyle, Priestley, and Cavendish had lived and died. Stahl's theory of phlogiston had held sway for many years but had at last yielded to the sledge-hammer blows of Lavoisier. Qualitative methods were being supplemented by quantitative. Proust, by refinements on the existing quantitative procedures, had put Berthollet to rout and thus the law of definite proportions was confirmed. Dalton had, only a few years previously, in 1803, outlined his atomic theory at the Royal Institution. Gay-Lussac had discovered the simple relation existing between the volumes of gases in a chemical reaction. Avogadro had even announced his famous hypothesis but it had made no impression upon the rather static thought of his time. Prout's idea of one primordial substance had arrived.

COTTING'S "INTRODUCTION TO CHEMISTRY," 1822

Thus many large issues had been fought out. But what are some of the chief limitations of that period? First of all, the old idea of caloric, although staggering under the buffets of Count Rumford, was still in the running. The theory of ionization was not to appear until sixty-five years later. Chemistry was practically a unit and was only later to be divided into organic, inorganic, physical, etc. The zero group was unknown. Radium, with its train of unifying theory, was undiscovered. Atomic and molecular weights were in a chaotic condition, and systematic colloid chemistry was unknown. Rational ideas of valence were waiting to be

expressed by Frankland and Kekulé. No attempt at a periodic classification of the elements had been made. The period of iatro-chemistry had pointed out the relation of chemistry to medicine but nothing had been accomplished.

Into such an atmosphere the freshman chemist stepped in 1822. We are not agreed today as to what should be given to this inquiring soul. Perhaps there was not complete agreement on this subject in 1822, and it should consequently be interesting to see how one author looked at the matter. One such viewpoint may be studied in John Ruggles Cotting's "An Introduction to Chemistry, with Practical Questions: Designed for Beginners in the Science. From the Latest and Most Approved Authors to Which Is Added a Dictionary of Terms." Cotting was "Lecturer on Natural and Experimental Philosophy, Chemistry, and Botany." The preface is dated Boston, May 10, 1822, the book having been published in May, 1822, by Charles Ewer, No. 51, Cornhill, Boston, and printed by True and Greene. It consists of four hundred and twenty pages.




TITLE-PAGE OF COTTING'S CHEMISTRY
The first three words, "An Introduction to" are torn off.

The author states in his preface that "The science of chemistry is considered as a part of a polite and liberal education for both sexes, and is taught in most of the literary institutions of the country." As to the scope of chemistry he says:

Chemistry is not confined to one department of nature, it takes a wide range through all the works of creation, and subjects all material bodies to its laws..... Chemistry extends itself into all the minute concerns of active life, and is the fostering hand of innumerable important arts, and the various discoveries made in the science are so many acquisitions to those arts.

Again in chapter one we find:

Chemistry is the science which investigates the combinations of matter, and the agencies of those general forces whence these combinations are established or subverted..... The subjects of chemical inquiries are particles of matter, both the magnitude and form of which, and the distances within which they act upon each other, are wholly incapable on account of their extreme minuteness to be estimated.

The proper method of teaching is given as the "interrogatory method," and many questions are listed at the close of each chapter.

Much may be inferred as to the nature and content of Cotting's teaching from the thirty-eight chapter headings.

1. Definition—General Law of Matter
2. Of Elements or Simple Bodies—Chemical Attraction or Affinity
3. Theory of Atoms—Definite Proportions—Chemical Equivalents
4. Of Light—Caloric
5. Of Combined Caloric
6. Of Oxygen
7. Of Azote or Nitrogen
8. Of Hydrogen
9. Of Sulphur
10. Of Phosphorus
11. Of Carbon
12. Of Alkalies
13. Of the Decomposition of Alkalies and Earths
14. On the Earths
15. Of Magnesia—Alumina—Yttria—Glucina—Zirconia—Silica—and Thorina
16. Of the Acids
17. Continuation of the Acids
18. Of Oxygen Acids—Metallic
19. Of Hydrogen Acids
20. Acids of Organic Origin
21. Of Chlorine
22. Of Iodine
23. Of Salts in General
24. Of Electricity—Voltaic Electricity
25. Of Metals
26. Of Platinum—Gold—Silver—Palladium—Mercury
27. Of Copper—Iron—Tin—Lead—Nickel—Cadmium—Zinc
28. Of Bismuth—Antimony—Manganese—Cobalt—Tellurium
29. Of Arsenic—Chromium—Molybdenum — Tungsten — Columbium—Selenium—Osmium
30. Rhodium—Iridium—Uranium—Titanium—Cerium—Wodanium
31. Of Prussine or Cyanogen
32. Of the Nature and Composition of Vegetables
33. Of Coloring Matter—Decomposition of Vegetables—Fermentation
34. Continuation of Fermentation
35. Of Vegetation
36. Of the Animal Department
37. Of Respiration
38. On Animal Heat—A Dictionary of Chemical Terms

The laboratory work is introduced in connection with the discussions. There are 225 items labeled as experiments but many others are suggested or indicated in the textual matter. It is distinctly an experimental treatment, with a tendency to include much that might be classed as sensational. The appeals to the eye and the ear are quite evident, and most of the directions are simple and direct. Some examples are given.

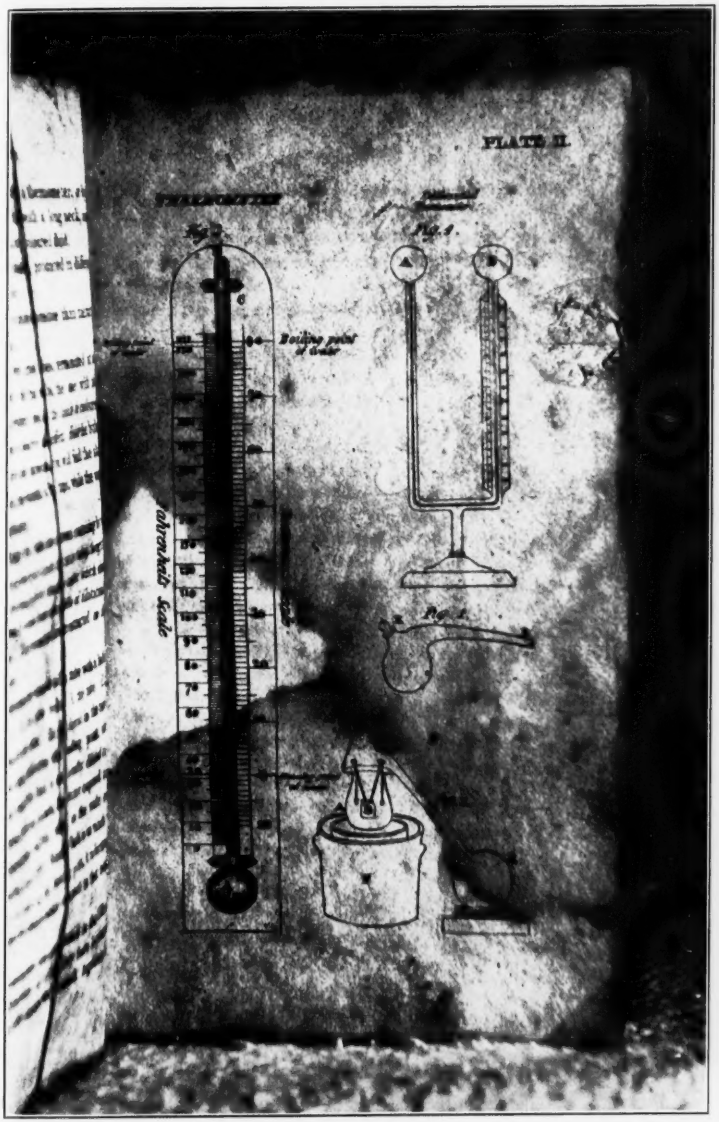



ILLUSTRATION OF APPARATUS AND DEVICES USED BY COTTING

Fig. 1. A retort. Fig. 2. Union of sulfur with alcohol. *A*, a cucurbit. *B*, a phial containing alcohol. *C*, the head. *F*, the lamp. *X*, the matrass. Fig. 3. A thermometer. Fig. 4. Leslie's air thermometer.

Throw a piece of potassium about the size of a pin's head on the surface of water, it swims and burns with a beautiful light, mixed with red and violet.

Heat an iron bar red hot, and apply to it a roll of sulphur, the latter becomes melted, and the drops that fall will be found to be a sulphuret of iron.

Balance a large funnel of paper in a pair of scales, and pour carbonic acid into it from a spout of a jar, when that end of the balance will descend; this shows that it is heavier than atmospheric air.

To procure ammoniacal gas, mix one ounce of powdered sal ammoniac with two ounces of quick lime, put the mixture into a common flask, and apply a lighted lamp or candle to the bottom; ammoniacal gas will rise in abundance.

Take strong nitric acid and pour a few drops into a glass, containing oil of turpentine, a violent inflammation immediately ensues. This experiment succeeds best when a little sulphuric acid is added with the nitric.

Immerse a small quantity of sulphuret of antimony, powdered, into a jar containing chlorine, it will immediately take fire and burn spontaneously, the result will be chloride of antimony. The same effect will take place with copper, tin, arsenic, and zinc, in powder.

Put two grains of chlorate of potash in powder in a mortar, and add one grain of sulphur. Mix them very accurately by gentle triture, and then having collected the mixture to one part of the mortar, press the pestle upon it suddenly and forcibly, a loud detonation will ensue.

The experiments on some topics sound remarkably modern. For instance on hydrogen we have listed as experiments or referred to as such the following: 1. Making hydrogen soap bubbles. 2. Preparation by action of iron or zinc filings on sulfuric acid (this is stated to be a decomposition of water). 3. Decomposition of water by the voltaic battery, catching the gases either together or separately. 4. Decomposition of water by passing steam through a red hot gun barrel. 5. Production of water by sparking a mixture of hydrogen and oxygen. 6. Making a "philosophical candle" by lighting a stream of hydrogen made from iron filings and sulfuric acid. 7. Production of noise "similar in some measure to an Eolian harp" by holding over the hydrogen flame a glass tube about two feet in length and one inch in diameter. 8. Burning hydrogen under a tumbler to produce water. 9. Explosion of hydrogen soap bubbles. 10. Explosion of mixed hydrogen and oxygen soap bubbles. 11. Making carburetted hydrogen gas by heating coal. 12. Making phosphine.

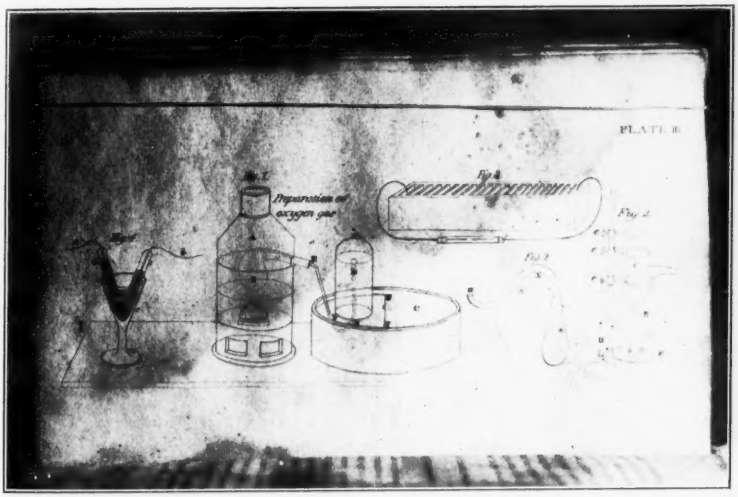
Cotting's style is rather colorless. His book is admittedly a compilation. Each chapter consists of short numbered paragraphs. Chemical and physical properties, historical references, experiments and observations are intermingled in each chapter on the elements. The treatment is largely factual. The theory is dealt with separately for the most part and aside from that concerning equivalents, light and caloric, is non-existent.

What is our student taught about caloric? Cotting says:

What is denominated heat is a sensation produced by a substance called caloric which penetrates all bodies, diminishes the attraction of their several parts, and uni-

formly expands their dimensions. By means of this powerful agent, solid metals are fused; liquids rarified; and almost all substances are converted into elastic, compressible, or aeriform fluids.

Caloric is said to be either free or radiant, when it is called heat or temperature, or combined, when it does not affect the thermometer or our senses and "is retained in our bodies by the force of affinity or attraction, and becomes a part of their substance." Heat is said to be different from caloric in that one is the cause and the other is the effect. Liquids are solids which have




COTTING'S EXPERIMENTS WITH OXYGEN AND HYDROGEN

Fig. 1. Preparation of oxygen in quantity, using $MnO_2$. *A*, furnace. *B*, iron retort or bottle. *C*, pneumatic cistern or water bath. *D*, a jar. *E*, a tube. Fig. 2. Preparation of oxygen in quantity, using red oxide of lead. *C*, retort. *D*, stand. *EF*, Argand's lamp. Fig. 3. Collection of hydrogen by decomposition of water. Fig. 4. Collection of oxygen and hydrogen separately in electrolysis. *ab*, wires connected to battery. *cd*, tubes. *e*, glass of water.

combined with a larger proportion of caloric than they contain naturally. Water is vaporized because of the caloric forcing itself in between the water particles, causing them to separate so far that their attractive power is lessened. The steam becomes visible again upon contact with cool air because of the loss of caloric. A "late theory" says that

Caloric is composed of particles perfectly separate from each other, every one of which moves with great velocity in a certain direction. These directions vary infinitely, the result of which is, that there are rays or lines of these particles, moving with immense velocity, in every possible direction. Caloric then is universally diffused, so that when

any portion of space happens to be in the neighborhood of another, which contains more caloric, the colder portion receives a quantity of calorific rays from the latter sufficient to restore an equilibrium of temperature. This radiation not only takes place in free space, but extends also to bodies of every kind. Thus you may suppose that every body whatever, is continually sending forth rays, when the body is surrounded with an elastic medium, or in a vacuum.

All bodies are conductors to some degree at least of caloric. Specific and latent caloric are discussed in the same way as specific and latent heat today. The production of ice is of course accompanied by a loss of caloric. In this connection an interesting theory is given to account for the increase in volume of water on freezing. The volume becomes greater because air which has been held in solution is liberated upon freezing, the air forming cavities in the ice.

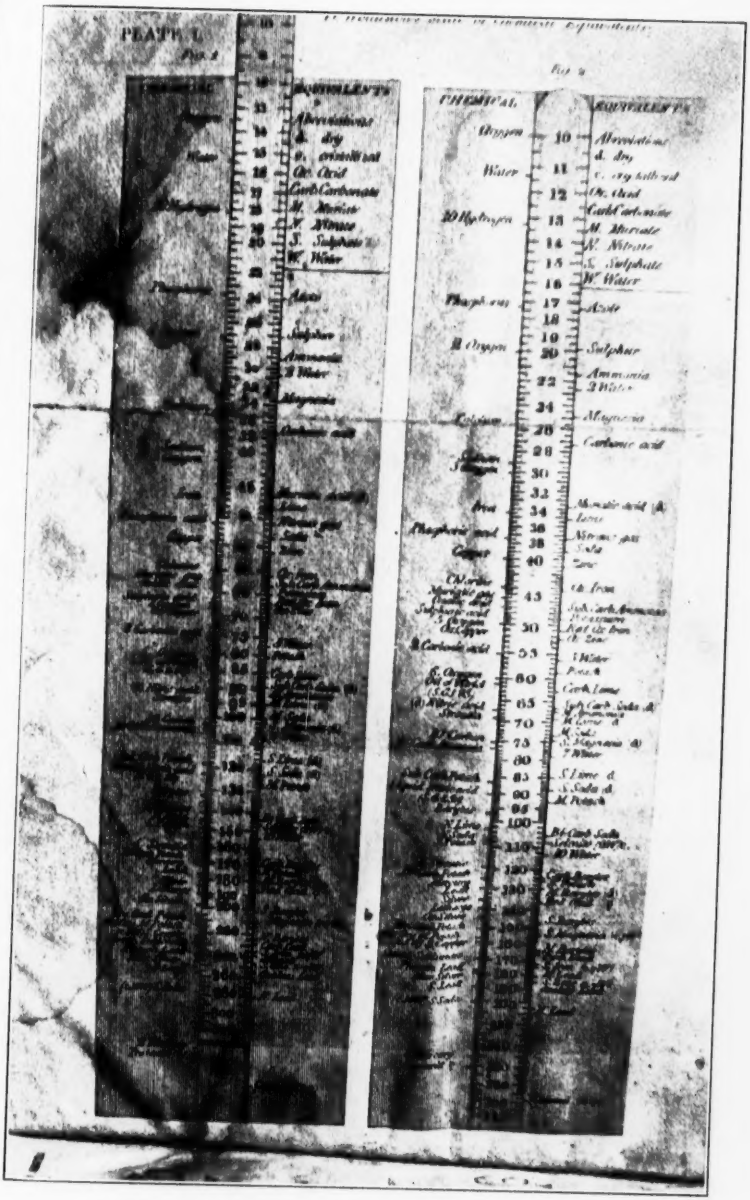
Atomic weights had not yet arrived, but equivalent weights were very much in vogue. There were three systems used: 1. One with oxygen as a basis. 2. One with one volume of hydrogen as the base. 3. One having two volumes of hydrogen as the base. The last was based upon the work of Dalton and assumed that two volumes of hydrogen contained the same number of atoms as one volume of oxygen. The values in the first system were said to be convertible into those of the second by multiplying by sixteen.

It is to Dr. Wollaston that we owe the term chemical equivalents, "to express the different ratios in which the corpuscular subjects of this science reciprocally combine, referred to a common standard which is reckoned unity." Oxygen was his standard. A short table of his values is given. Combination in multiples and sub-multiples of these values was clearly understood.

| | | | |
|---|---|---|---|
| Oxygen | 1.000 | Calcium | 2.550 |
| Fluor? | 0.375 | Sodium | 2.950 |
| Hydrogen | 0.125 | Potassium | 4.950 |
| Carbon | 0.750 | Copper | 8.00 |
| Phosphorus | 1.500 | Barium | 8.75 |
| Azote | 1.750 | Lead | 13.00 |
| Sulphur | 2.000 | | |

Richter worked upon the question of equivalence existing between acids and bases and concluded: "1st, That the quantity of two alkaline bases, sufficient to neutralize equal weights of any one acid, are proportionable to the quantities of the same bases sufficient to neutralize the same weights of every other acid." He spent the years 1791 to 1802 in verification of his conclusions, giving us the following table.

| Bases | Oxygen = 1 | | Acids | Oxygen = 1 | |
|---|---|---|---|---|---|
| Alumina | 525 | 2.625 | Fluoric | 427 | 7.135 |
| Magnesia | 615 | 3.075 | Carbonic | 577 | 2.885 |
| Ammonia | 672 | 3.36 | Sebacic | 706 | 3.530 |



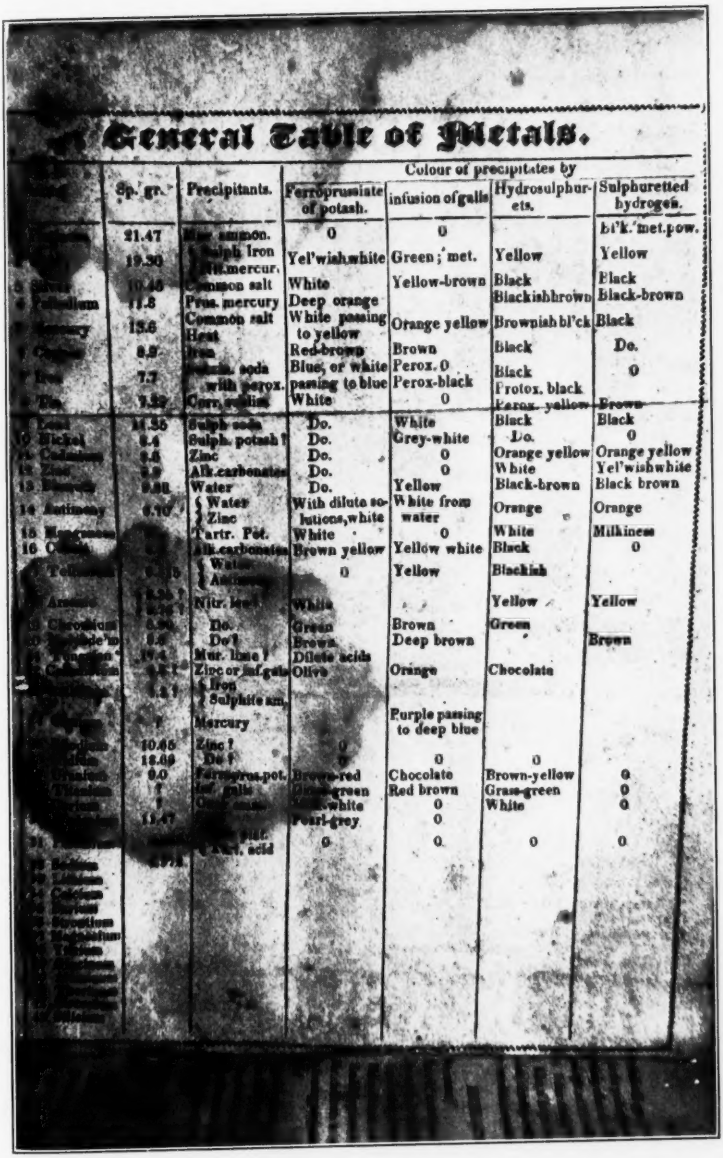

WOLLASTON'S SCALE OF CHEMICAL EQUIVALENTS

| Bases | Oxygen = 1 | | Acids | Oxygen = 1 | |
|---|---|---|---|---|---|
| Lime | 793 | 3.965 | Muriatic | 712 | 3.560 |
| Soda | 859 | 4.425 | Oxalic | 755 | 3.775 |
| Strontium | 1229 | 6.645 | Phosphoric | 679 | 4.895 |
| Potash | 1605 | 8.025 | Formic | 988 | 4.94 |
| Barytes | 2222 | 1.111 | Sulphuric | 1000 | 5.000 |
| | | | Succinic | 1209 | 6.045 |
| | | | Nitric | 1405 | 7.025 |
| | | | Acetic | 1480 | 7.400 |
| | | | Citric | 1483 | 8.415 |
| | | | Tartarous | 1694 | 8.470 |

This table may be interpreted as follows. Potash has a value of 1605 by it. This means that 1605 parts by weight will neutralize 427 parts by weight of fluoric acid, 712 of muriatic, 1000 of sulfuric, and so on.

It was Wollaston, however, who gave a table of chemical equivalents which "has done more to facilitate the general study and practice of chemistry, than any other invention." He took the most trustworthy analyses made to that date and arranged a large number of substances on one or the other side of a scale running from 10 to 320 in the order of their relative weights. The value of the arrangement was such that when the name of a compound was opposite the value on the sliding scale equal to its relative weight, you could then read off the weight of any "ingredient" in its molecule, or of any reagent that might be used or precipitate that could be had, on the sliding scale opposite the name of the substance in question. Now putting Wollaston's table to the test we move the slider until the name sodium chloride is opposite 100, its equivalent weight, on the slider. The following tabulation shows the values appearing opposite the various compounds listed and also calculations to compare the old ratios with modern ones. The column headed W represents the value for each substance divided by the corresponding value of sodium chloride. The column headed "Mine" was obtained by dividing the modern molecular weight of each compound by a weight of sodium chloride equivalent to it. 1925 atomic weights were used. It is noticed that agreement is very close in all cases

| Table value | | W | Mine |
|---|---|---|---|
| 100 | Sodium chloride | ... | ... |
| 46.4 | Hydrogen chloride | 0.464 | 0.624 |
| 39.8 | Sodium | 0.398 | 0.393 |
| 281 | Lead nitrate | 2.81 | 2.833 |
| 191 | Litharge | 1.91 | 1.909 |
| 237 | Lead chloride | 2.37 | 2.739 |
| 143 | Sodium nitrate | 1.43 | 1.454 |
| 232 | Mercuric chloride | 2.32 | 2.323 |
| 91.5 | Ammonium chloride | 0.915 | 0.915 |
| 84 | Sulphuric acid | 0.84 | 0.839 |
| 122 | Sodium sulphate | 1.22 | 1.215 |
| 277 | Sodium sulphate, decahydrate | 2.77 | 2.756 |



## General Table of Metals.

| | Sp. gr. | Precipitants. | Colour of precipitates by: Ferroprussiate of potash. | infusion of galls | Hydrosulphurets. | Sulphuretted hydrogen. |
|---|---|---|---|---|---|---|
| | 21.47 | Nitr. ammon. | 0 | 0 | | bl'k. met.pow. |
| | 19.50 | Sulph. iron | Yel'wishwhite | Green; met. | Yellow | Yellow |
| | | Nit.mercur. | | | | |
| | 10.45 | Common salt | White | Yellow-brown | Black | Black |
| | 11.8 | Prus. mercury | Deep orange | | Blackishbrown | Black-brown |
| | 13.6 | Common salt | White passing to yellow | Orange yellow | Brownish bl'ck | Black |
| | 8.9 | Heat | Red-brown | Brown | Black | De. |
| | 7.7 | Iron | Blue, or white | Perox. 0 | Black | 0 |
| | 7.32 | Caust. soda with perox. | passing to blue | Perox-black | Frotox. black | |
| | | Corr. sublim. | White | 0 | Perox. yellow | Brown |
| | 11.35 | Sulph soda | Do. | White | Black | Black |
| | 8.4 | Sulph. potash | Do. | Grey-white | Do. | 0 |
| | 6.8 | Zinc | Do. | 0 | Orange yellow | Orange yellow |
| | 8.9 | Alk.carbonates | Do. | 0 | White | Yel'wishwhite |
| | 9.88 | Water | Do. | Yellow | Black-brown | Black brown |
| | 6.70 | Water | With dilute so- | White from | Orange | Orange |
| | | Zinc | lutions, white | water | | |
| | | Tartr. Pot. | White | 0 | White | Milkiness |
| | | Alk.carbonates | Brown yellow | Yellow white | Black | 0 |
| | | Water | 0 | Yellow | Blackish | |
| | | Antimony | | | | |
| | | Nitr. lead | White | | Yellow | Yellow |
| | | Do. | Green | Brown | Green | |
| | | Do? | Brown | Deep brown | | Brown |
| | | Mur. lime | Dilute acids | | | |
| | | Zinc or inf.gals | Olive | Orange | Chocolate | |
| | | Iron | | | | |
| | | Sulphite am. | | | | |
| | | Mercury | | Purple passing to deep blue | | |
| | 10.45 | Zinc? | 0 | | | |
| | 13.69 | De? | 0 | 0 | 0 | |
| | 9.0 | Ferrosprus.pot. | Brown-red | Chocolate | Brown-yellow | 0 |
| | | Inf. galls | Grass-green | Red brown | Grass-green | 0 |
| | | Oxy. muriat. | Milk-white | 0 | White | 0 |
| | 11.47 | Nitr. silver | Pearl-grey | 0 | | |
| | | Nitr. plat. | 0 | 0 | 0 | 0 |
| | | Nitr. acid | | | | |

Cotting's Characterization of the Metals
The text also reveals an attempt at classification.

except hydrochloric acid. As numerous errors were located with certainty, it may be that this is an error in the lay-out of the table itself.

No symbols, formulas, or equations appear anywhere in the book.

The total number of elements is referred to as fifty. No table of the elements is given but thirty-eight are discussed. A table of the metals is included, listing the following: Platinum, gold, silver, palladium, mercury, copper, iron, tin, lead, nickel, cadmium, zinc, bismuth, antimony, manganese, cobalt, tellurium, arsenic, chromium, molybdenum, tungsten, columbium, selenium, osmium, rhodium, iridium, uranium, titanium, cerium, wodanium, potassium, sodium, lithium, calcium, barium, strontium, magnesium, yttrium, glucinum, aluminum, thorium, zirconium, and silicium. Also the table gives for each of the first thirty-two the specific gravity; precipitants; and color of any precipitates by ferroprussiate of potash, hydrosulfurets, and sulfuretted hydrogen. It is not to be understood that all the metals referred to had been isolated. The non-metals, elsewhere described, include oxygen, nitrogen, hydrogen, sulfur, phosphorus, carbon, chlorine, and iodine. Thus we have a total of fifty-one elements.

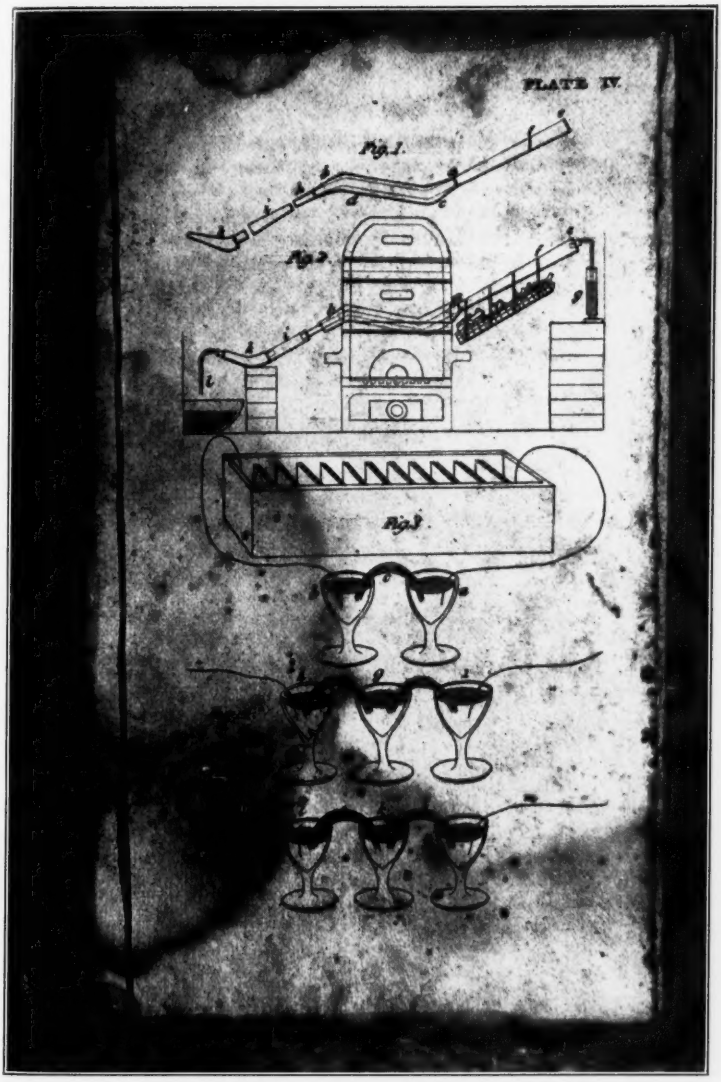
As it appears somewhat difficult for modern authors to characterize metals to the satisfaction of the student, I will quote Cotting:

> Metals are the most numerous class of undecompounded chemical bodies; and are distinguished by the following properties. 1. They possess a peculiar lustre, which continues in the streak, and in their smallest fragments. 2. They are fusible by heat, and in fusion, retain their lustre and opacity. 3. Except selenium, they are all excellent conductors of caloric and electricity. 4. Many of them may be extended under the hammer, and are called malleable; or under the rolling press, and are called laminable; or drawn into wire, and are called ductile.

An attempt is made at classification of the metals. In the list of thirty-eight given above, the first twelve and numbers thirty-one, thirty-two, and thirty-three are said to be malleable. The first sixteen give oxides which are "neutral salifiable bases." Numbers seventeen to twenty-three inclusive are "acidifiable by their combining with oxygen." Numbers thirty-one and on combine with oxygen to form bases. Little is known about the oxides from twenty-three to thirty-one.

The definition of acids, bases, and salts are about as illuminating to the freshman as some we find in certain modern texts. Acids: "They consist of a certain base, called a radical, and an acidifier." General properties are: sour taste; combine with water in every proportion; mostly volatilized and decomposed by heat; usually change purple colors of vegetables to red; unite in definite proportions with earths, alkalies, and metallic oxides.

This classification of acids is worthy of notice. In general we have acids from the inorganic realm and those of organic origin. The former are divided into three families: oxygen acids, hydrogen acids, and acids without oxygen or hydrogen. The first family is further divided into a




LABORATORY PROCEDURES OF A CENTURY AGO

Figs. 1, 2. Preparation of potassium. Fig. 1 is a gun barrel. *a* to *b*, the part exposed to the heat. *c* to *a*, part filled with clean iron turnings. *e*, opening through which potash is introduced. *e* to *f*, empty. *e*, curved glass tube. *g*, vessel nearly filled with mercury. *ik*, recipient of copper. *l*, curved tube opening under surface of mercury. Fig. 3. Decomposition of salts by electricity. *AB*, glasses containing solution of sulfate of soda. *A* is positive and contains litmus. *B* is negative and contains sirup of violets. *C*, moistened cotton thread. Fig. 4. Same as Fig. 3, except that middle glass contains only sulfate of soda, the two others distilled water colored as before. Fig. 5. No reference. Apparently same as Fig. 4.

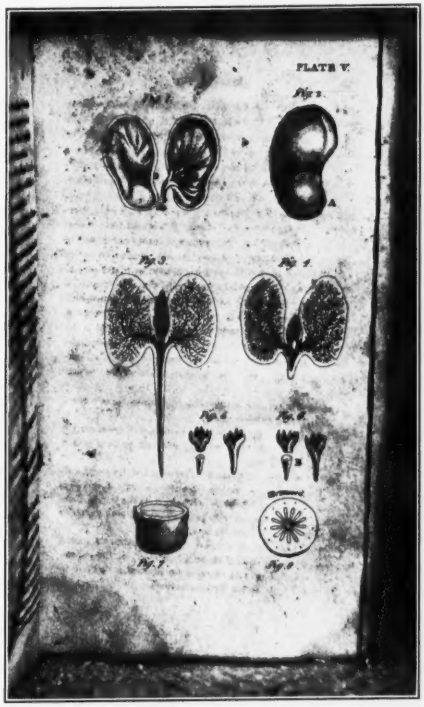
non-metallic section and a metallic section. The non-metallic section of the first family includes boracic, carbonic, chloric, perchloric, chlorocarbonous, nitrous, nitric, iodic, hypophosphorus, phosphorus, phosphoric, hyposulfurous, sulfurous, sulfuric, hyposulfuric, and cyanic. The metallic section includes arsenic, arsenious, antimonious, antimonic, chromic, columbic, molybdic, molybdous, and tungstic. In the second family we find fluoric, hydriodic, hydrochloric, ferroprussic, hydroprussic, hydrosulfurous, hydrotellurous, and sulfuroprussic. In the third family there are chloroidoic, chloroprussic, fluoboric, and fluosilicic. The organic acids are aceric, acetic, amniotic, benzoic, boletic, camphoric, caseic, citric, formic, fungic, gallic, kinic, laccic, lactic, lampic, lithic, malic, meconic, menispermic, margaric, melassic, mellitic, moroxylic, mucic, oleic, oxalic, purpuric, pyrolithic, pyromalic, pyrotartaric, rosacic, saclactic, sebacic, suberic, succinic, sulfovinic, tartaric, and zumic. Thus we see a total of seventy-five acids.

Bases are not mentioned as such but are called alkalies. They are characterized by "caustic or urinous" taste, have affinity for water; change blue vegetable colors to green, brown to yellow, and yellow to orange; corrode animal substances; make soaps with oils and fats; unite with acids to form salts; can be fused and volatilized by heat. The alkalies mentioned are: 1. Fixed: potash, soda, and lithia. 2. Volatile: Ammonia. Salts: "The term salt is usually employed to denote a compound in definite proportion, of acid matter, with an alkali, earth, or metallic oxide." Salts are characterized as follows: 1. Volatilized by heat. 2. Black precipitate caused by "hydrosulfuret of potash." 3. White precipitate usually caused with hydrochloric acid. 4. Yellow precipitate caused by gallic acid.

The nomenclature presents some contrasts with modern practice. In the naming of oxides, compounds with one "portion" of oxygen are called protoxides; with two, deutoxides; with three, tritoxides; and with the greatest proportion, a peroxide. The compound of phosphorus and lime, evidently calcium phosphide, is called phosphuret of lime, and the gas given off upon being thrown into water is phosphuretted hydrogen gas. The combination of sulfur with lime is sulfuret of lime. The combination of selenium with sulfur, phosphorus, the earths, and metals are referred to as seleniurets. Most other naming is similar to that used today.

A few points of incidental interest are noted. Mayow is given as the discoverer of oxygen, in 1674. The aphlogistic lamp, or lamp without flame, is described as being a coiled hot platinum wire suspended in ether fumes over liquid ether. The platinum becomes red hot and remains so as long as the ether lasts. Synthetic nitric acid was made by passing electric sparks through a mixture of nitrogen and oxygen in a glass tube. The old method of making mirrors is explained; an amalgam of mercury

and tin foil is placed on a marble slab and the glass "slided" on it and held down with weights. Iron may be distinguished from steel by the iron having a whitish grey spot but the steel a black spot when treated with nitric acid. The formation of the lead tree is said to be caused by galvanism. The chameleon mineral is formed by putting powdered manganese and potassium nitrate into a red-hot crucible; a product is obtained that shows different colors depending on the quantity of water put with it; a small amount of water gives green, more gives blue, and still more causes purple. The analysis of vegetables yields thirty-two substances: sugar, sarcocol, asparagin, gum, ulmin, inulin, starch, indigo, gluten, albumin fibrin, bitter principle, extractive matter, tannin, fixed oils, wax, volatile oils, camphor, birdlime, resins, guaiacum, balsams, caoutchouc, gum resins, cotton, suber, wood, emetin, fungin, hematin, nicotin, and pollenin. The analysis of animal substances yields the following: gelatin, albumen, fibrin, caseous matter, coloring matter of the blood, mucus, urea, picromel, osmazome, sugar of milk, and sugar of diabetes. A table of the order of conductivity for electricity begins with copper, silver, gold, iron, etc., and ends with rarefied air, dry earths, and massive minerals (metallic). A list of non-conductors in the order of insulating power begins with shellac, amber, resins, sulfur, wax, etc., and ends with ice below zero degrees Fahrenheit, oils of which the densest are best, and dry metallic oxides, including alkalies and earthy hydrates. They were onto the teaspoon-melting-in-coffee trick even in 1822 as we




A PAGE OF ILLUSTRATIONS FROM COTTING'S EXCURSION INTO THE PLANT WORLD

Figs. 1, 2. *A*, radicle. *B*, plumula.
Fig. 3. Cotyledons transformed into leaves.
Fig. 4. Divisions of the seminal root.
Fig. 5. Transverse section of the radicle.
Fig. 6. Transverse section of the plumula.
Fig. 7. Transverse section of the bean.
Fig. 8. Silver grain of wormwood.

find: "Melt eight parts of bismuth, five of lead, and three of tin together, and when united, the compound is so fusible that a spoon made of it will melt in boiling water." While due mention is made of the idea of light being a wave motion, still it is taken "by most philosophers" as a material substance. Thermometers used were Fahrenheit mostly, then Centigrade, De Lisle's (boiling point = 0, freezing point = 150), air thermometers, and Wedgewood's pyrometer. Sir H. Davy is quoted as saying that gases owe their permanent elasticity to the presence of either positive or negative electricity.

The "Dictionary of Terms" includes some rare items. *Aerial acid* is carbonic acid. *Aludel* is a vessel used in sublimation. *Apyrous* means resistance to heat. *Athanor* is a furnace used by ancient chemists. *Aurum Musivum* is a combination of tin and sulfur, the bisulfuret of tin. *Bistre* is a brown pigment made of the finer parts of wood soot. *Butters of metals*, an old term for chlorides, is used. *Dephlegmation* is the process of removing water from a substance. The *docimastic art* is the art of assaying metals. *Edulcoration* means the purification of a substance by washing with water. *Eliquation* is the separation of one substance from another by fusion. *Fecula* is starch. *Ferruretted chyazic acid* is ferroprussic acid. *Fuligenous:* "vapors which possess the quantity of smoke." *Magistery* is an old term for precipitate. *Phlogisticated acid* is nitrogen. *Phlogisticated alkali* is ferroprussiate of potash. *Phlogiston* is the inflammable principle of the old chemists. *Sal catharticus amorus* is magnesium sulfate. *Tombac* is a white alloy of copper and arsenic, also called white copper.

Thus, John Ruggles Cotting has shown us how chemistry was presented to beginners in 1822. A comparison with present-day information is instructive as showing through what stages our knowledge has come.

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**Beryllium Was $5000, Now $50.** When we remember that aluminum was a curiosity metal a generation ago, and see what the once rare metal tungsten has done in electric lighting, we have our interests whetted for beryllium, the hardest of the light metals, which was scarce at $5000 a pound seven years ago, but has now been brought down to $50, with prospects of a reduction to $10 within a few years.

Beryllium is related to the emerald, weighs only two-thirds as much as aluminum, is very hard, scratching glass easily, is the color of steel, takes a high polish, remains untarnished in the air, and transmits to almost any metal with which it is alloyed a resistance to corrosion, as well as strength.

At present, it is recovered from feldspar waste heaps in New Hampshire, and as the cost comes down, it will be used to harden aluminum, copper, nickel, and silver, and to produce "rustless" irons and steels. Its salts are sweet, its nitrate is used for impregnating gas mantles, and it gives passage to X-rays seventeen times as freely as aluminum, heretofore used for this purpose.—*Chem. & You*

# HYDROGEN-ION CONCENTRATION FROM THE THERMODYNAMIC AND ELECTROCHEMICAL POINT OF VIEW

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## Theoretical Discussion

Sorenson's method of expressing the concentration of hydrogen ions as pH, or the logarithm of the reciprocal of the actual concentration of hydrogen ions, has proved to be a convenient system to designate the strength of weak acids and bases, and also a very useful means of studying the properties of industrial and physiological solutions.

The principles involved in expressing the concentration of hydrogen ions in pH and converting the latter back into numbers of normality may be briefly illustrated by the following examples:[1]

$$\frac{N}{100} = \frac{N}{10^2} = 1 \times 10^{-2}\, N = 0.01\, N;\ \text{pH} = \log \frac{1}{0.01} = \log 1 - \log 0.01 = 0 - (-2) = 2$$

$$\frac{N}{1000} = 1 \times 10^{-3}\, N = 0.001\, N;\ \text{pH} = \log \frac{1}{0.001} = \log \frac{1}{10^{-3}} = \log 10^3 = 3$$

$$\frac{N}{500} = \frac{2N}{1000} = 2 \times 10^{-3} = 0.002\, N;$$

$$\text{pH} = \log \frac{1}{2 \times 10^{-3}} = \log \frac{10^3}{2} = \log 10^3 - \log 2 = 3 - 0.301 = 2.699$$

$$\frac{18N}{1{,}000{,}000} = \frac{18N}{10^6} = 18 \times 10^{-6} = 1.8 \times 10^{-5};$$

$$\text{pH} = \log \frac{1}{1.8 \times 10^{-5}} = \log \frac{10^5}{1.8} = \log 10^5 - \log 1.8 = 4.7447.$$

To convert pH back into normality:

$$\text{pH} = 2 = \log \frac{1}{x} = -\log x,\ \log x = -2,\ x = 10^{-2} = 0.01.$$

$$\text{Again pH} = 2.699 = \log \frac{1}{x} = -\log x,\ \log x = -2.699,$$

but the abscissa of the logarithm is always positive, therefore we subtract the decimal part from 1 and add to the characteristic $-1$, then $\log x = \bar{3}.301$; $x = 2 \times 10^{-3}$ or 0.002. For ordinary purposes the pH values of solutions may be approximately determined by the use of proper indicators.[1]

In spite of its convenience, this twisted method of expression would perhaps lose much weight for its justification if it were not for the energy relation which it indicates clearly. In explaining this relation from thermodynamic and electrochemical principles, the treatment of the subject, while far from being rigorous or exhaustive, is believed to be comprehensive enough to convey a fair understanding of the ionic functions of solutions

[1] R. H. Ashley, "Hydrogen-Ion Concentration," THIS JOURNAL, **5**, 1647–58 (Dec., 1928).

and dispel a good deal of mystery with which this branch of study is surrounded in the minds of students.

Gaseous elements that ionize in a solution behave like metals. Hydrogen gas is an example.

If we dip a plate of platinized platinum (having a spongy surface) in a solution containing hydrogen ions and bubble a steady current of hydrogen gas under one atmospheric pressure around the plate, hydrogen gas will be adsorbed on the rough surface of the plate until the latter is saturated. Under this condition the plate will act as a hydrogen electrode: either atoms of hydrogen will pass from the plate into the solution as ions, leaving electrons on the plate, if the solution is weak with respect to hydrogen ions; or the ions will deposit on the plate, rendering the latter positively charged, if the solution is strong with respect to hydrogen ions. In either case there will be a potential difference between the plate and the solution which may be measured as a single electrode potential.

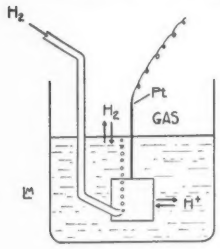


FIGURE 1

This potential difference or electrical energy may be calculated theoretically from thermodynamic considerations. The fundamental principle is that the ions in dilute solutions obey the gas law, acting as if a gaseous mass were compressed into the volume of the solution:

$$PV = RT \tag{1}$$

$P$ means ionic pressure or concentration, $V$ = the volume of the solution, $T$ = absolute temperature, and $R$ = gas constant.

Let us imagine that a limited number of hydrogen ions pass from the electrode into the solution. The volume of the solution will be practically the same, but the pressure (or concentration) of the ions will be increased by an infinitesimal amount, which may be indicated by the expression $dP$. The ions passing into the solution (or into the atmosphere in a gaseous state, as the case may be) do a certain amount of work $dW$. This change in energy will be:

$$dW = VdP \tag{2}$$

but from the gas law we have

$$V = \frac{RT}{P} \tag{3}$$

Substituting the value of $V$ in (2) we get

$$dW = \frac{RT}{P}\,dP = RT\,\frac{dP}{P} \tag{4}$$

Evidently this expression lies within the domain of simple differential calculus, which may be integrated within definite limits.

$$W = RT\int_{P_2}^{P_1}\frac{dP}{P} \tag{5}$$

Those who are not familiar with differential and integral calculus naturally feel handicapped when they see such expressions, but they may take for granted certain conventions in the study of the elements of physical chemistry.[2] Infinitesimal quantities that approach certain limits are marked by d before the symbol of quantity, and the expressions such as $dP$ are called differentials. The differentials $dE$, $dP$, etc., may be integrated to their proper quantities according to certain rules. When a differential expression is to be integrated, it is marked with a symbol of integration as $\int dE = E + C$ (a constant); when it is to be integrated between desired limits the process is called definite integration and the limits are marked above and below the integration symbol.

$$\int_{E_2}^{E_1} dE = E_1 + C - (E_2 + C) = E_1 - E_2$$

Coming back to our equation (5) we see that our differential is divided by its own whole quantity $dP/P$. The integral of such expressions is always equal to the natural logarithm or 2.3026 times the common logarithm of the quantity, thus:

$$\int\frac{dP}{P} = \ln P + C \text{ (a constant)}$$

$$\int\frac{dx}{x} = \ln x + C = 2.3026 \log x + C$$

$$\int\frac{dV}{V} = \ln V + C$$

The expression, ln, stands for natural or Naperian logarithm and $C$ for some constant dependent on the case. But the integration in our case is within definite limits, namely, within the limits of the initial and final concentration. The symbol of integration shows the limits $\int_{P_2}^{P_1}\frac{dP}{P}$, where $P_1$ and $P_2$ represent respectively the strong and weak solutions. In the process of definite integration, the constant $C$ is cancelled. It follows that the definite integration of (5) will give

$$W = RT\int_{P_2}^{P_1}\frac{dP}{P} = RT\,(\ln P_1 - \ln P_2) = RT\ln\frac{P_1}{P_2} \tag{6}$$

The osmotic pressure of the hydrogen ions is determined by their concentrations; therefore $P_1$ and $P_2$ representing the pressure of the ions, may be substituted by $C_1$ and $C_2$ representing their respective concentrations:

[2] Those without adequate preparation in mathematics are referred to "Mathematical Preparation for Physical Chemistry," Farrington Daniels, McGraw-Hill & Co., 1928.

$$W = RT \ln \frac{C_1}{C_2} \tag{7}$$

If the stronger solution is a normal solution ($C_1 = 1$), our equation will be further simplified,

$$W = RT \frac{1}{C_2} \tag{8}$$

As we usually deal with common logarithms, we may convert the natural log into common log by multiplying the expression with the constant 2.3026, thus:

$$W = RT\ 2.3026 \log \frac{1}{C_2} \tag{9}$$

But by definition $\log 1/C_2 = \text{pH}$, accordingly equation (9) becomes

$$W = RT\ 2.3026\ \text{pH} \tag{10}$$

This means that the energy of the system may be measured and pH or $\log 1/x$ (where $x$ = concentration of the unknown solution) may be determined directly. $W$ = electrical work = volts $\times$ current.

In the transfer of one gram atom of hydrogen ions one Faraday (or 96,500 coulombs) of electric current is used, therefore,

$$W = \text{volts} \times 96{,}500 = RT\ 2.3026\ \text{pH} \tag{11}$$

Electromotive force (potential difference) or volts = e. m. f. = $E$ and

$$E = \frac{RT\ 2.3026\ \text{pH}}{96{,}500}, \tag{12}$$

the number of volts we read on the potentiometer; $T$ is the absolute temperature under which the experiment is performed.

As long as the measurement is taken in electrical units, $R$ must be converted into joules (mechanical equivalent of electrical energy). This is done from our fundamental equation,

$$\frac{PV}{T} = R$$

$P$ is the pressure in atmospheres, and $V$ is the volume in cubic centimeters, molar volume being 22,400 cc.

One atmosphere pressure is equal to the weight of a mercury column 76 cm. high and 1 sq. cm. in cross-section, the specific gravity of mercury being 13.596.

One atmosphere = $76 \times 13.596 = 1033.3$ grams. Convert this into energy units, ergs, by multiplying it with the gravitational constant, $1033.3 \times 980.6 = 1{,}013{,}254$ ergs, and finally convert it into joules by dividing by 10,000,000 (number of ergs in one joule). Now taking the value of $PV/T$, we have

$$\frac{PV}{T} = \frac{1{,}013{,}254 \times 22{,}400}{10^7 \times 273} = R = 8.32\ \text{(joules/cc.)}$$

Therefore the electromotive force or the voltage, $E$, between the limits of our concentration at 25° will be:

$$E = \frac{RT\ 2.3026}{96{,}500} \log \frac{1}{C_2} = \frac{8.32 \times 298 \times 2.3026\ \text{pH}}{96{,}500} = 0.059\ \text{pH} \qquad (13)$$

$$\text{If } C_2 = 0.1 \text{ normal, pH} = \log \frac{1}{0.1} = \log 10 = 1$$

Then the voltage between $N/10$ and $N$ limits will be

$$E = 0.059 \times 1 = 0.059 \qquad (14)$$

This means that for each ten-fold change in the concentration of a solution, change in energy will be 0.059 volt at 25°C. If the concentration is unknown, the potential difference between the hydrogen electrode and the solution may be measured as $E = 0.059$ pH. Now $E$ being known

$$\text{pH} = \frac{E}{0.059} = E \times 16.9 \qquad (15)$$

If $E$ is 0.2 volt, pH = $0.2 \times 16.9 = 3.38$, and if we wish to convert this value to figures of normality we have pH = log $1/x$ = 3.38, $-\log x$ = 3.38, log $x$ = —3.38; subtract 0.38 abscissa from 1 and add —1 to —3, then log $x = \bar{4}.62 = 6.62 - 10$; $x$ = antilog $\bar{4}.62 = 4.169 \times 10^{-4}$ normal.

## The Method of Measurement

To measure the single potential between an electrode and the solution of its ions involves difficulties and requires great skill. Comparatively, it will be a simple matter to balance an unknown solution against a standard solution of hydrogen ions, say, a normal one. Let each solution have its hydrogen electrode in the form of platinized platinum saturated with hydrogen gas under atmospheric pressure; the two solutions may be connected through a porous partition or by a bridge or inverted U-tube containing one of the solutions with cotton

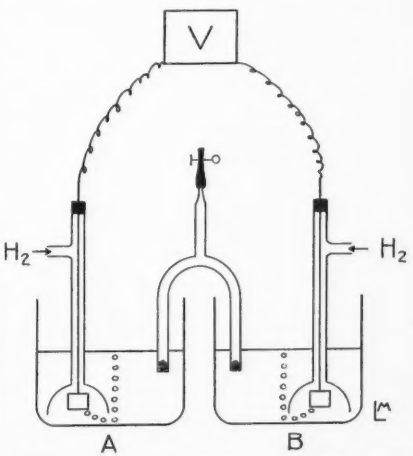



FIGURE 2.—SHOWING METHOD OF MEASUREMENT OF HYDROGEN-ION CONCENTRATION

*A*—Reference solution and spongy platinum electrode; *B*—unknown solution and its electrode; *V*—voltmeter.

The bridge connecting two solutions may contain one of the solutions with cotton plugs at the two openings, or may be prepared from a saturated potassium chloride solution and about six per cent agar while hot, which solution on cooling will be rigid.

plugs to prevent convection or siphoning. The electrodes may be connected externally through a voltmeter. Under these conditions there will be a potential difference recorded, which is the result of the algebraic sum of the potential difference between each electrode and its solution and also at the liquid junction between the two solutions. The potential at the liquid junction, being very small, may be neglected for our purpose.

We may write our two potentials separately as:

$$E_1 = -\frac{RT}{F} \ln C_1 = -0.059 \log C_1, \tag{1}$$

$$E_2 = -\frac{RT}{F} \ln C_2 = -0.059 \log C_2 \tag{2}$$

$E_1$ is the potential of the reference solution $C_1$ and $E_2$ is that of the unknown solution $C_2$. Subtract (1) from (2).

$$E_2 - E_1 = \frac{RT}{F} \ln C_1 - \frac{RT}{F} \ln C_2 = \frac{RT}{F} \ln \frac{C_1}{C_2} = 0.059 \log \frac{C_1}{C_2} \tag{3}$$

$$E_2 = E_1 + 0.059 \log \frac{C_1}{C_2} \tag{4}$$

If $C_1$ is normal, its potential is 0.27 volt. We read the value of $E_2 - E_1$ or $0.059 \log C_1/C_2$ on the voltmeter, and then the potential of the unknown solution may be determined by adding the potential of the standard or reference solution (0.27 volt in case of one normal in hydrogen ions) to our reading. It is almost impossible to prepare a reference solution exactly normal in hydrogen ions. Various stable buffer solutions are prepared and their hydrogen-ion concentration is determined, which may serve as a reference solution, but all of them need checking against the most stable calomel cell.

For the most exact measurement a potentiometer is used instead of a voltmeter. Any ordinary variable dry or wet battery with a rheostat is used to balance against a standard Weston cell, in order to secure a reliable direct reading on the potentiometer. After this balancing, the switch is thrown from the Weston cell to hydrogen-calomel cells without changing the position of the battery and rheostat, and a direct reading of $E_2 - E_1$ is obtained.

$$\text{Now } E_2 - E_1 = 0.059 \log \frac{1}{C_2} = 0.059 \text{ pH}$$

but the value $E_1$ for saturated calomel cell is known as 0.246. Subtract this value from the potentiometer reading and divide by 0.059 to get the pH of the unknown solution as

$$\text{pH} = \frac{e - 0.246}{0.059}$$

The following diagram shows the make-up of the calomel cell and the setting of the apparatus for measurement:

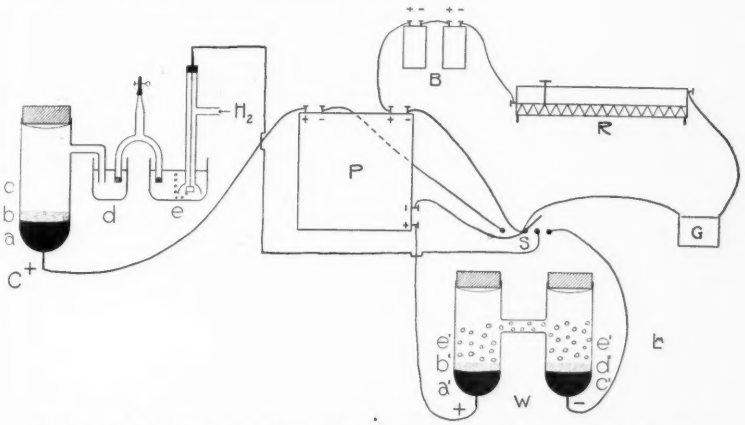



FIGURE 3.—SHOWING THE MAKE-UP OF THE CALOMEL CELL AND THE SETTING OF THE APPARATUS FOR MEASUREMENT

*C*—Calomel cell
*a*—Mercury
*b*—Calomel paste
*c*, *d*—Saturated KCl solution
*e*—Unknown solution with platinum-hydrogen electrode
*P*—Potentiometer (some potentiometers have a special place for galvanometer)
*R*—Rheostat
*G*—Galvanometer
*B*—Dry or storage batteries
*S*—Switch
*W*—Standard Weston cell
*a'*—Mercury
*b'*—Paste of cadmium and mercurous sulfate
*c'*—CdHg amalgam
*d'*—Small crystals of $CdSO_4$
*e'*—Saturated solution of $CdSO_4$ and large crystals of the same

If the reading of the potentiometer is 0.480 volt, the value of pH is 0.480 − 0.246 = 0.059 pH.

$$\text{pH} = \frac{0.234}{0.059} = 3.967$$

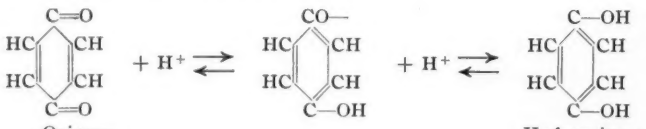
The hydrogen electrode is somewhat tedious to manipulate and often fails to work satisfactorily for various reasons. The platinum must be platinized first by electrolysis in a solution of platinic chloride for about 20 seconds. After this the electrode must be washed and saturated with hydrogen by electrolysis in a dilute sulfuric acid solution for about 20 minutes. After washing again it is ready to use. It is claimed that the electrode can be used for about 20 measurements.

All this trouble and waste of time and material may be eliminated by using a quinhydrone electrode, which is much simpler and also reliable.[2]

In this case, instead of using hydrogen gas a pinch of quinhydrone is used around the platinum electrode, and it is not necessary to platinize the lat-

[2] Above about pH 8 the quinhydrone electrode is not so reliable: the first reading on the potentiometer is probably nearest to the potential of the system.

ter. The equilibrium between hydrogen of quinhydrone and hydrogen ion of the solution is reached in a very short time and stays fairly constant. The equilibrium is illustrated as follows:




A strong acid solution will shift the equilibrium toward the right. Even the calomel half cell as a reference electrode may be eliminated, and in its place a $M/20$ solution of potassium acid phthalate may be used with a platinum electrode and a little quinhydrone. The pH value of the latter solution is definitely known as 3.98 at 25°C. The setting of apparatus for quinhydrone electrode is the same as given above, with the elimination of hydrogen gas. In case acid phthalate is used as a reference solution, the bridge joining this with the unknown solution may contain half saturated potassium chloride solution, prepared with about five per cent agar, which, on cooling, will gelatinize the content of the bridge and make it a good conductor. The bridge must be kept in a saturated potassium chloride solution.

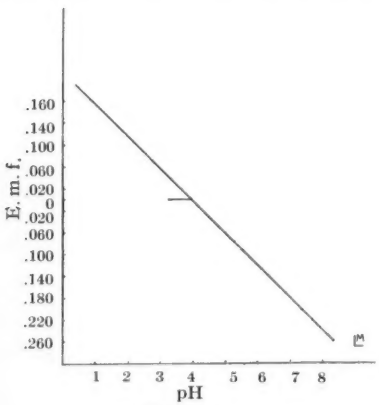



FIGURE 4

Ordinate—Readings on the potentiometer.

Abscissa—pH of solutions determined against $M/20$ acid phthalate using quinhydrone around the platinum electrodes. Gold may be used instead of platinum.

Above 0 volts and below pH 3.98 the potential is positive, below 0 volts and above pH 3.98 it is negative.

The method of calculation of pH of an unknown solution against acid phthalate solution at 25° is as follows:

Reading on the potentiometer, $E = 0.059 \times 3.98 = -0.059$ pH (unknown).

Suppose the reading is 0.070 volt (unknown being on the negative side): $-0.070 - 0.059 \times 3.98 = -0.059$ pH

$$\text{pH} = \frac{305}{59} = 5.17$$

If the unknown solution is positive against acid phthalate solution (which means greater hydrogen-ion concentration in the unknown), then our equation will be:

$$0.070 = 0.059 \times 3.98 - 0.059\ \text{pH}$$

$$-\text{pH} = \frac{0.070 - 0.059 \times 3.98}{0.059} = \frac{-165}{59}$$

$$\text{pH} = 2.8$$

If the concentration of hydrogen ions in the unknown solution is the same as in the reference solution of $M/20$ acid phthalate, the potential difference between the two electrodes will be zero, because the number of hydrogen atoms passing from each electrode into the surrounding solution as ions will be the same, and therefore the number of electrons given to each electrode will be the same. But if one of the solutions is weaker, in a given time more hydrogen atoms will pass in ionic state into that solution, causing more electrons to accumulate on its electrode; the pressure of electrons being greater on this electrode, the negative electricity (electrons) will flow from it through the wire and potentiometer into the opposite electrode, and the negative ions from the strong solution will migrate toward the electrode of the weak solution. This means that the weaker solution will have the negative electrode while the stronger will have the positive.[3]

The curve given below is plotted from the potential difference between $M/20$ potassium acid phthalate and solutions of various hydrogen-ion concentration. pH values may be read directly against volts or e. m. f. readings of a potentiometer, whether negative or positive.

[3] According to the old idea positive electricity entered from the electrode into the weaker solution, hence the more negatively charged electrode was called anode, while the other was named cathode.

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**Industrial Motion Picture Films.** The Motion Picture Bureau of the National Council of the Young Men's Christian Association, 120 West Forty-First St., New York, N. Y., has recently started a collection of 16-mm. films on industrial subjects, in addition to its extensive list of 35-mm. films. These films are loaned free of charge except for costs of transportation. The following 16-mm. films are now available:

No. 1699—*The Romance of Glass*, 1 reel
No. 1664—*Putting the Win in Windows*, 1 reel
No. 1628—*From Pigs to Paint*, 2 reels
No. 1645—*School Days*, 1 reel
No. 1604—*The Grape Industry*, 1 reel
No. 1639—*The Magic Jar*, 1 reel
No. 1695—*Bradford on Mt. Washington*, 1 reel
No. 1640—*The Transformation*, 2 reels
No. 1601—*Happy Hours*, 2 reels
No. 1605—*Treasures and Flavors*, 2 reels
No. 1692—*Inside Out*, 1 reel

Industrial films relating directly or indirectly to chemistry are also obtainable from the U. S. Rubber Co., B. F. Goodrich Co., International Harvester Co., Westinghouse Electric Co., General Electric Co., Hammermill Paper Co., U. S. Steel Corp., Eastman Kodak Co., and General Motors Corp.—*News Ed., Ind. Eng. Chem.*, **7**, 4 (July 10, 1929).

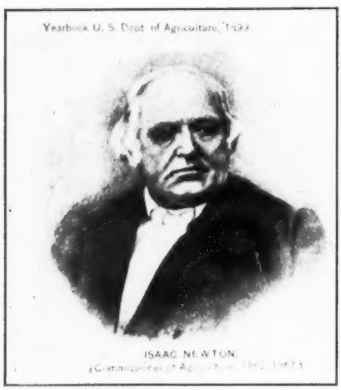
# CHARLES MAYER WETHERILL, 1825–1871. PART IV*

EDGAR FAHS SMITH

## Chapter V

## Chemist of the Department of Agriculture

Wetherill's appointment by President Lincoln as Agricultural Chemist of the Department of Agriculture, the first scientist to take office in this department, was confirmed by the following letters—the first in the neat handwriting of the clerk of the Department and the second in the crabbed script of Commissioner of Agriculture Newton himself.




*Yearbook U. S. Department of Agriculture, 1899*

ISAAC NEWTON

Commissioner of Agriculture, 1862–1867.

Washington, July 28, 1862.

Charles W. Wetherill, Esq.

Dear Sir.

Your letter of the 22 inst. accepting the position of Agricultural Chemist under the Department of Agriculture came duly at hand. You will report to me for duty at your earliest convenience.

The salary will be sixteen hundred dollars.

In reply to your question relating to board, I can only say that the price will depend entirely upon the accommodations wanted. The city is not at all crowded at present, and I presume you could make satisfactory arrangements for board for yourself and family.

Yours very respectfully,

*Isaac Newton*

Per W. E. Gardiner.

Washington, D. C., Aug. 8th, 1862

Doctor Charles M. Wetherill.

Respected Friend.

I received your letter dated the 31st. I am pleased to find by your letter that you are willing to connect your labours with the Agricultural Department. I am confident many practical and valuable results will emanate from your long experience in chemistry. I have been strongly impressed for many years (with) the great importance of chemistry as an important branch of agriculture. I am confident with proper aid and assistance in this new department we can make it equal if not superior to any similar department in the world. I am pleased to know that I shall have a Wetherill as a chemist in my department. I have the most exalted opinion of their superior talents in that branch of science. I am ready to receive you when it is convenient for you to get to Washington.

I remain your sincere friend,

*Isaac Newton.*

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* This is the last manuscript from the pen of the late Edgar Fahs Smith.

P.S. Profes. Henry of the Smithsonian said we can, at any time they are informed, use his laboratory, a superior one.

I. N.

Upon leaving Lafayette to begin his duties with the government, Wetherill was given a letter by the Mayor of the city certifying that:

The bearer of this, Mr. Chas. M. Wetherill, is a citizen of this place and entirely loyal to the Government of the U. S. Mr. W. has been appointed, by the President, Agricultural Chemist of the Department of Agriculture at Washington, and desires to go to Washington to enter upon his official duties. He is not seeking to evade the drafting law or any other law whatever.

His fellow members of the Grand Union Club, of which he was secretary, also presented him upon the eve of his departure for Washington with the following resolutions:

*Whereas* our friend and worthy brother, Chas. M. Wetherill, M.D. having been called from our midst to occupy the highly honorable position as Chemist in the Agricultural Department recently established by an Act of Congress. *Therefore Resolved:* That in the departure of our beloved brother, our community loses a valuable citizen, and one too, whose place we look in vain to be filled—one who has ever been ready to perform valuable services, not only as a citizen, but as a man of science. *Resolved:* that his services to us as an organization have been such that words are too feeble to express our appreciation of his value as our worthy secretary. *Resolved:* That in the departure of our beloved brother, we offer him our heartfelt gratitude for his kindly offices to us and pledge our cordial sympathy to follow him in his new field of labor.

The transition from the pleasant community relations which he had enjoyed at Lafayette during the previous five years to wider duties in the service of the nation no doubt appeared to Wetherill an important step in advance. His new position not only gave him an unequaled opportunity to undertake useful original researches but it carried with it a large amount of prestige. His appointment seemed to be regarded as something in the nature of general chemical adviser to the government and although requested by Commissioner Newton to begin his duties as chemist on August 21, 1862, Wetherill, immediately upon his arrival in Washington, was detailed by President Lincoln upon special service and was not remanded to the Department of Agriculture until the close of October.

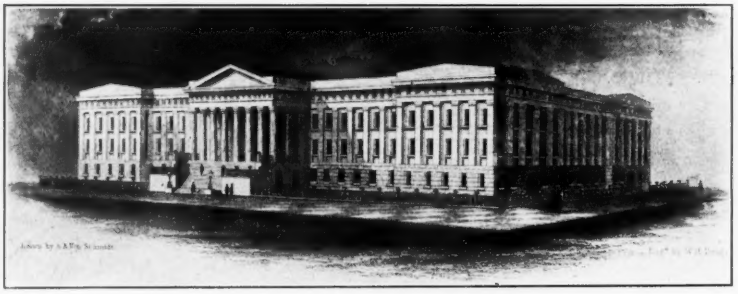
The laboratory which Wetherill equipped for his new duties as Agricultural Chemist occupied one of a half dozen rooms in the basement of the Patent Office Building which were assigned to the Department of Agriculture as its first place of occupation. The place was of the dark subterranean character, which was supposed by many officials of earlier days to be necessary for all properly constituted chemical laboratories.

A single room such as is now occupied is entirely inadequate for a national laboratory. Scales, brass apparatus and even chemicals are damaged by the great dampness

prevailing, to which the acid fumes, sometimes unavoidably generated, must always add. There is no space even to arrange my private library necessary for constant reference.

So wrote Dr. Henry Erni of the Department of Agriculture laboratory in 1864, and this condition applied for many years to come. All honor to that scattered band of early American chemists who, working with limited facilities in dismal surroundings, were yet able to add so many foundation stones to the structure of our science!

Although with only two months at his disposal for the organization of his laboratory and the initiation of his work, Wetherill was able on January 1, 1863, to submit the first annual "Report of the Chemist of the Department of Agriculture," the only scientific report to be submitted in the first year of this Department's history.



U. S. PATENT OFFICE AS IT EXISTED ABOUT 1860
It was in the basement of this building that Dr. Charles Mayer Wetherill established his laboratory as the first Chemist of the Department of Agriculture.

The agricultural chemist of today who reviews this first report of Wetherill is impressed not only by the large number of analyses, which he performed in so short a time with so scant an equipment, but also by the very practical interpretation of his results. Wetherill inaugurated the scientific work of the Department of Agriculture with a chemical examination of 24 varieties of American grapes. The results of the analyses are presented and useful comments are made upon the utilization of the different varieties for wine production. On account of the interest attaching to the subject, a preliminary 6-page "Report on the Chemical Analysis of Grapes" by Wetherill, was issued by Commissioner Newton in the latter part of 1862 as a separate publication, which may, therefore, be regarded as the first scientific bulletin to be issued by the Department of Agriculture.

In addition to his researches upon grapes, Wetherill's annual report as chemist of the department contains a chemical investigation of 15 different samples of sorghum and imphee canes, a discussion of the analyses of 18 samples of sorghum and imphee sirups and of 18 samples of sugar derived

from imphee, sorghum, sugar beets, and sugar canes. These last-named investigations and their extensive references to improvements in the technical processes of sirup and sugar manufacture mark the initiation of the Department of Agriculture's important series of investigations upon the chemistry and technology of sugar-producing plants, which have continued unbroken from Wetherill's first researches in 1862 down to the present time.

An interesting picture of Wetherill's activities as departmental chemist is given in the following account of a contemporary newspaper reporter:

*A Visit to the Laboratory of the Department of Agriculture.*

In this age of scientific agriculture chemistry has a part to play in directing the practical working of the earth; and accordingly the Commissioner has devoted one of the rooms appropriated to his department to the use of a chemical laboratory.

Yesterday, while in pursuit of items, we strolled into this room, and found Dr. Wetherill, who has charge thereof, busy with his various labors of analyzing different articles. After examining some of the many samples of sugars, sirups, wines, etc., that are there awaiting their turn to be analyzed, the Doctor exhibited to us a list of the results of the work he has already performed, and which list he is now preparing for the next report of his department.

In his analysis of grape juice he has sought to determine its density, quantity of sugar, acid, etc., from which it is hoped practical men may gain information in aid of the manufacture of wine. These analyses, however, the Doctor tells us, are only introductory of the subject; that, another year, it is designed to select samples of the same varieties of grapes from all sections of the States, and thereby give to the results a practical value, applicable all over the States. These analyses will also give exhibits of the soils in which grapes produce the most of valuable elements for good wine; and also the locations, or rather sections, where such elements, in connection with the soil, are best eliminated.

Many analyses have also been made of the different varieties of imphee and sorghum, both of the cane, the sirup, and also the sugar, exhibiting the percentage of juice in the canes, its crystallizing properties, defecation, etc., from which to aid and instruct the practical man, both in the growth as well as the manufacture of imphee or sorghum canes into pure white sugar. In pursuance of the subject, the doctor has also exhibited the capabilities of the cane for forming wine, spirits, etc.—items which, however applicable they may be, we hope will never be put in use to a very great extent; for we confess to a feeling that the grape, and the grape only, was created for wine, and that only wine of pure grape juice is of beneficial use to man in his daily food.

The next system of analysis that it is designed to have pursued is that of native wines, and to this end steps are being taken to collect samples from all the various sections of our States, together with a statement as to the general character of the soil in which the vines were grown that produced the grape from which the wine was made. This analysis of wines is to be followed by analyses of grapes, next fall, from the same vineyards that produced the wines; and thus Professor Wetherill will be enabled to give such a table of results that grape growers can tell at a glance where the soil and climate is situated to produce the best grapes, or the variety best adapted to the making of good wine.

An interesting observation made by Wetherill in the Department of Agriculture laboratory upon the contamination of ether by absorption of

the vapors of fusel oil from the air was published in the *Proceedings of the American Philosophical Society* for March 20, 1863 (p. 171).

In addition to his laboratory duties at the Department of Agriculture, Wetherill had to answer many letters relating to the various applications of chemistry to agriculture. This correspondence was of a very miscellaneous character. Only one letter (written by a distinguished contemporary who afterwards became president of the American Chemical Society, upon a subject which has always been of the utmost interest to the chemists of the Department of Agriculture) will be quoted:

CHARLES MAYER WETHERILL, FROM A PHOTOGRAPH TAKEN WHILE HE WAS CHIEF CHEMIST, DEPARTMENT OF AGRICULTURE

Philadelphia, December 26th, 1862

My dear Doctor:

Your kind letter was duly received and I thank you for it. I communicated it to Mr. Lumbrock, but not having seen him since I do not know how his matters stand.

The object of my present letter is to make some inquiries with reference to the *Paper* made of *Cornstraw*, of which, as I understand, some samples have lately been sent to the Agricultural Bureau by the inventor, a Baron von Weisbach* or Nelsbach of Vienna. Believing that the connections of my house are such as to make it advantageous both to the inventor and ourselves to have his agency in the U. S., I have already taken steps in Vienna to make the necessary arrangements. This was done, however, before I had seen any publications with reference to this matter, or even before the name of the discoverer had appeared in the newspapers. Some of the papers give it as Nelsbach, others as Weisbach. What is it? Would you have the goodness to inform me whether the inventor has already an agent in this country and, if so, who is it? Any other data

* The name of which Dr. Genth was in doubt is Dr. Alois Ritter Auer von Welsbach, at that time Chief Director of the Imperial State-Printing Establishment in Vienna and of the Imperial Paper-Mill at Schlögelmühle, Austria. He had developed a process for manufacturing textiles, paper, and other industrial products from Indian corn wastes, which was described in a pamphlet, printed on maize paper, for the Austrian Exhibit at the International Exhibition of 1862. This pamphlet (printed in English) is still of great interest in view of the present revival of projects for the industrial utilization of corn stalks.—C. A. B.

which in your judgment might be of service to me in the accomplishment of my design would be most thankfully received. Is it in your power to obtain any samples of the paper for me? In the hope of being able to reciprocate, for which you will always find me ready, I remain

Yours truly,
*F. A. Genth.*

Wetherill, being the first and only official in the entire federal service at that time to hold the title of chemist, was frequently called upon, as were many of his successors, to render special services to the government that were not of an agricultural nature. And so it happened that in the spring of 1863 Wetherill was again called upon by President Lincoln to conduct a confidential investigation. Commissioner Newton was authorized to give his Chief Chemist leave of absence for the execution of this commission in the following executive order.

Executive Mansion.
Washington, April 4th, 1863.

Dear Sir:

You will please detail Dr. C. M. Wetherill, Chief Chemist, and F. G. Murray, Esq., both of your department, for special service to report to Capt. I. R. Diller at Philadelphia, Pa., for one month from date, also giving Dr. Wetherill permission to close his laboratory in the Agricultural Department during that period and to take its key with him for the security of its contents during his absence.

Yours truly,
*Abraham Lincoln.*

The Commissioner of Agriculture.

The special service mentioned in this order was a continuation of the previous assignment already mentioned, and required the investigation by Wetherill of a secret powder, invented by a German named Hochstätter and submitted by his agent Ricker to the U. S. Government for use in its military operations against the armies of the seceding states. Captain Isaac R. Diller of the War Department was first approached in the matter and he was detailed to collaborate with Wetherill in this investigation which was conducted at Philadelphia. The manufacture of sufficient quantities of the new powder, which was of the chlorate type, for artillery use, was found to require a longer period than one month and Wetherill was accordingly authorized by Commissioner Newton "to remain at Philadelphia until notified to the contrary." The final result of the tests led to the rejection by the government of the new powder on account of certain inherent defects, which it was found impossible to correct. Wetherill was then led to devise an entirely different chlorate powder with special adaptation to artillery use. The following two separate patents were issued by the United States Patent Office under the date of March 22, 1864, to Hochstätter and Wetherill.

No. 42,037, H. HOCHSTÄTTER. IMPROVED GUNPOWDER, MINING POWDER, ETC.

A composition of charcoal, potassium chlorate, half-calcined sea grass, stone coal and sawdust, or certain named substitutes, is formed in boiling water and dried; or mixtures of wheat flour and potassium chlorate, and stone coal and charcoal are made in mortars, intermixed in water, pressed into blocks, rubbed through a sieve and dried.

No. 42,056. C. M. WETHERILL. IMPROVEMENT IN GUNPOWDER, ETC.

A mixture of a suitable oxygen compound of chlorine with carbonaceous material is to be used in the proportion of 8 to 16 parts by weight of the former to 6 parts of the latter, to form either carbonic oxide or carbonic acid or a mixture of the said gases. Dextrine or other gum is to be added to form a grained powder. Peroxide of manganese facilitates the liberation of oxygen from the chlorates and oil of vitriol is designed to act on the chlorine compound, by appropriate means, to effect the explosion of the powder in shells as on striking an object.

Wetherill's patent, after the close of the war, was made the cause of a protest by the agent of the original Hochstätter process, as is shown by the following interesting letter of Capt. Diller.

Chicago, Feby. 9, 1866.

Dear Doctor:

A few days ago I was astonished at receiving a visit from my old friend Mr. Ricker from Frankfort A/M. You will recollect him as the person who sent over the powder secret of Hochstätter, whom from his singular writing you called "Old Chinese."

Well he thinks he can do something with the powder, or at all events he wants to show the parties in Frankfort when he returns that all that could be done with the Government has been done, and that the powder has been finally rejected and of course I am expected to transfer the patent to them—receiving a one-third interest in the same, as originally agreed upon.

But not only this, he seems to be of the opinion that as you were engaged in the manufacture of the powder and discovering defects patented the same as improvements, or as original powder, that the original parties have a right to your improvements and that all patents, predicted on this Hochstättter powder should take the same course, that is, $^2/_3$ to them, $^1/_3$ to you.

I have combated this idea, on the ground that after the Hochstätter patent issued it became public property under certain restrictions and any one had a right to patent any other powder if it did not infringe upon the right of the original inventor.

I think his claim wrong, but he is an old friend and I want to satisfy him that he is wrong. If I mistake not there was a previous patent for a chlorate powder to that of Hochstätter, and one or two, besides yours, since. Please find out at the Patent Office and write me.

If you wish to write Mr. Ricker his address is Samuel Ricker, care Robert Halsey, Esq., No. 168 Broadway, New York. So far as the Hochstätter powder is concerned, I am willing to assign the whole thing to them for peace, but under our agreement I cannot control your patent. I have told him of our troubles and trials and the science and ingenuity you exercised to make the German powder acceptable to the Government, and I defended you to the best of my ability and stated the reasons which induced you to patent what you did.

He has spent much money in this powder matter and feels sore about it but he will

not allow that others have spent money, time and risked much to benefit his German friends which is unjust. Write soon.

Your friend truly,
*Isaac R. Diller.*

Mr. C. M. Wetherill,
Smithsonian, Washington.

Wetherill's long detail from his duties at the Department of Agriculture on special government service not only aroused the interest of his friends, as is shown by the following note from his friend Professor Bache,

Washington.
May 27, 1863.

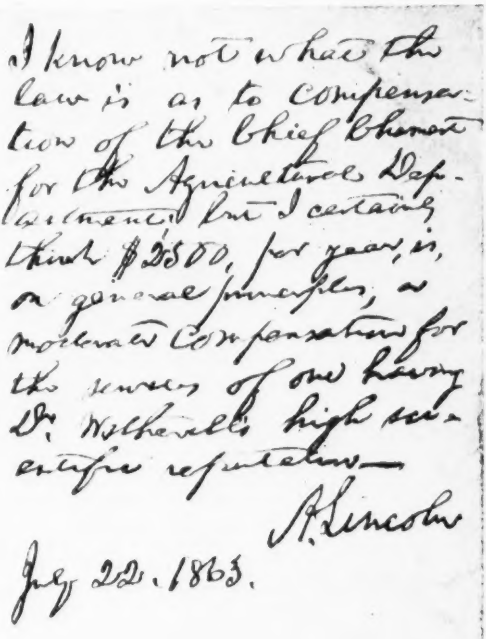
Dear Doctor.

I readily excuse an absence caused by so important a govt. service. Do tell me, when it suits you, more about that strange powder and when we come together in the same town do let us try to *see* each other, I beg you. I take the greatest interest in you and your affairs.

Truly yours,
*A. D. Bache.*

Doct. C. M. Wetherill.

but it also provoked the displeasure of Commissioner Newton who felt that the continued absences of his Chief Chemist on private government missions was causing a disruption of the scientific work and of his Depart-



I know not what the law is as to compensation of the Chief Chemist for the Agricultural Department but I certainly think $3500. per year is, on general principles, a moderate compensation for the services of one having Dr. Wetherill's high scientific reputation.

A. Lincoln

July 22. 1863.

Autograph Note of President Lincoln Respecting the Salary of C. M. Wetherill as Chemist of the Department of Agriculture

ment. That President Lincoln was pleased with the services rendered by Wetherill is evident from the following recommendation which he made for an increase in his salary:

I know not what the law is as to compensation of the Chief Chemist for the Agricultural Department, but I certainly think $2500 per year is, on general principles, a moderate compensation for the services of one having Dr. Wetherill's high scientific reputation.

*A. Lincoln.*

July 22, 1863.

but any evidences of the President's favor had no effect upon the Commissioner of Agriculture who declined to pay Wetherill any salary for the time on which he was detailed from his Department. Wetherill thereupon appealed to President Lincoln who wrote Commissioner Newton the following letter:

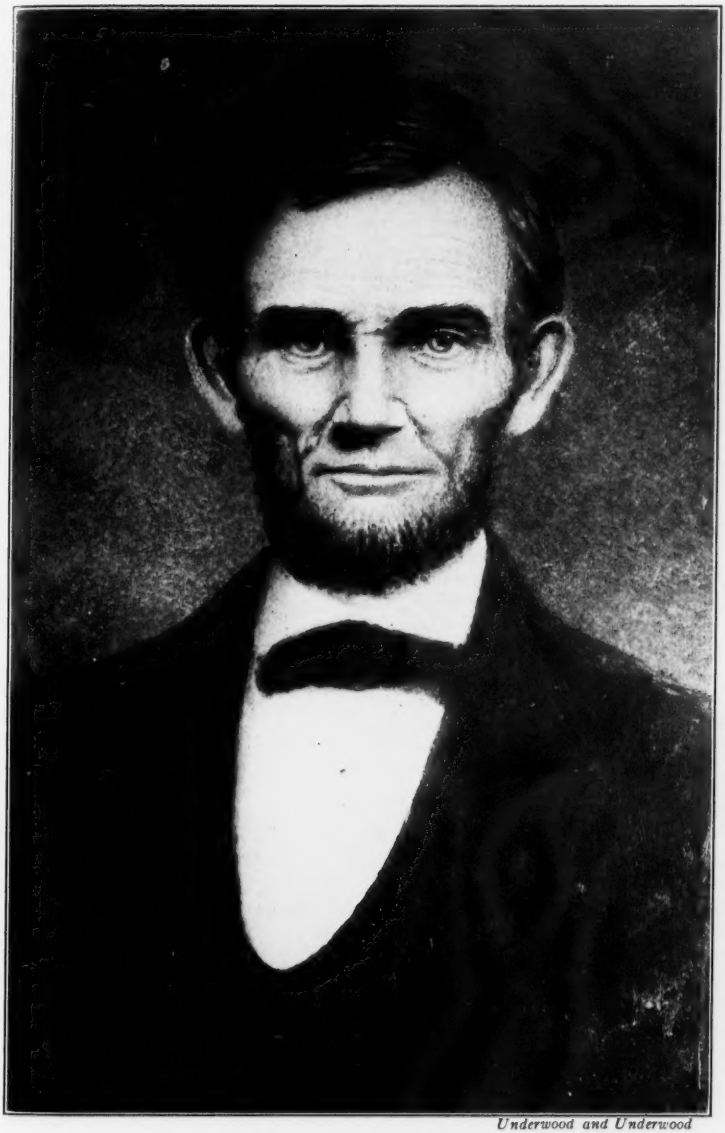
LETTER TO COMMISSIONER OF AGRICULTURE.

Executive Mansion, August 5, 1863.

Dear Sir: . . . About a year ago Captain Isaac R. Diller came to me with a proposition in regard to a new compound of gunpowder, the ingredients and mode of compounding being a secret. It promised important advantages, which would be very valuable, if the promise was made good. But he did not wish to give the government the secret; nor did the government wish to buy it without a test of its value. For this object, the manufacture of a quantity of it became indispensable; and this again required the service of a good chemist. Dr. Charles M. Wetherill, Chemist in your Department, was an acquaintance of Captain Diller, and was sought by him to aid in the manufacture of the powder. As I remember I requested you to allow him to do so, which you did. A small quantity was manufactured and proved so far satisfactory that Captain, now Admiral, Dahlgren advised the making of a large quantity so as to test it for artillery use. I consented, and procured the Secretary of War and Secretary of the Navy, to advance, from time (to time), sums amounting in the whole to five thousand dollars, from funds under their discretionary control. Dr. Wetherill's service was again required, and again obtained, perhaps so far as you are concerned, at my request. At the time, nothing was said, or thought of, so far as I remember, as to his receiving his salary at your Department, while engaged at the powder. Now, being brought to my mind it seems reasonable he should receive his salary for that time, which he tells me is refused. The manufacturer of the powder has required the building of a good deal of expensive machinery, leaving the five thousand dollars fund no reliance for Dr. Wetherill. In fact, I suppose Captain Diller thought the government was furnishing Dr. Wetherill, as one of its officers, to make the experiment.

Dr. Wetherill presents another question, which is as to the amount of his permanent or general salary. I see that the law fixes the salaries of a class to which the chemist belongs "corresponding to the salaries of similar officers in other Departments" and I do not see that the law assigns me any duty or discretion about it. All I can do is to give a sort of legal opinion that his salary should be fixed according to the law. I do wish these questions could be settled without further difficulty. I do not know what has been fixed as the salary of similar officers in other Departments; but I suppose this can not be hard to ascertain.

Yours very truly,
*A. Lincoln.*



*Underwood and Underwood*

PORTRAIT OF LINCOLN DONE FROM LIFE

Abraham Lincoln as he looked at the age of fifty-two as sketched by Freeman Thorp. This is the only portrait of Lincoln drawn entirely from life. Years after Lincoln died, Thorp, the painter of four presidents, studied the existing pictures of the great president but found none so true to life as his penciled sketch, which with his vivid memory of Lincoln, he used to paint this remarkable portrait of the emancipator.

Commissioner of Agriculture Newton not only ignored the requests of President Lincoln regarding Wetherill's salary and official station but he curtly informed Wetherill, upon the latter's return from detail to the laboratory of the Department, that his services were no longer needed. A summary dismissal of this kind was rightly regarded by Wetherill as a serious reflection upon his character and scientific reputation and being unable to obtain any satisfaction from Commissioner Newton he immediately appealed to his friends in Congress. Scientists are always interested in the efforts of distinguished members of their profession to defend their public services and as the dismissal of Dr. Wetherill was the first case to involve the investigation of the activities of a government chemist by a congressional committee the following extracts are made from the musty volumes of "The Congressional Globe:"

HOUSE OF REPRESENTATIVES

Tuesday, January 19, 1864.

The *speaker* announced the business first in order to be the following resolution, on which the main question was yesterday ordered, and the vote taken, no quorum voting:

*Resolved*, That a select committee of five members be appointed for the purpose of inquiring into the facts connected with the special details and absence from that Department of Dr. C. M. Wetherill, chemist of the Department of Agriculture; with power to send for persons and papers, and to report by bill or otherwise.

MR. ORTH asked consent to make a statement of the circumstances under which the resolution was offered.

No objection was made.

MR. ORTH. About a year ago a certain citizen of Illinois, whose name I do not now recollect, Captain Diller, I believe, brought to the notice of the President what he alleged was an improvement in gunpowder. The President directed that an investigation be made into the merits of this alleged new discovery; and in order to facilitate that investigation detailed Dr. Wetherill from the Agricultural Department.

Dr. Wetherill is well known to the country as one of the most scientific members of his profession. He commenced the discharge of his duties under this detail of the President, which was to terminate at the end of one month. At the expiration of that time, not having concluded his experiments, the Commissioner of Agriculture extended that detail indefinitely. The investigation was prosecuted during the summer months, and was concluded about the 1st of October. Dr. Wetherill then reported himself to the Commissioner of Agriculture, and found that he had been discharged.

Mr. Speaker, he is a constituent of mine. But whether a constituent of mine or not, I feel it to be my duty to bring forward the case of the humblest citizen of the Republic who feels aggrieved. I believe it likewise my duty to strike at the highest official in this Government, if necessary for the public welfare.

These are the facts. Dr. Wetherill is not a politician. He is a man of science. He thinks that his reputation is at stake in the way in which he has been treated. I ask, in his behalf, that the matter shall be investigated. From the time that he was detailed up to this day he has not received one dollar of his salary. It will not be proper for me to detail the interview which took place between the Commissioner of Agriculture and myself. Dr. Wetherill and his friends are willing that this matter shall be

publicly investigated. He believes that the effect of the action of the Department will be to cast a stigma upon his reputation as a scientific man. He entered the Department of Agriculture in pursuit of the science in which he was educated. It is in his behalf that I desire this investigation should take place.

The resolution provides for calling for persons and papers. There are only two witnesses cognizant of the whole transaction, and the investigation will occupy not more than one or two days. If the House wants the Committee on Agriculture to look into it, I have no objection. I do not see any pertinency, however, in sending it to that committee, any more than to the Committee on Enrolled Bills. It is a special matter, with which they have nothing to do.

THE SPEAKER. The previous question has been seconded and the main question ordered.

The resolution was adopted.

HOUSE OF REPRESENTATIVES

Wednesday, January 20, 1864.

The Speaker announced as the select committee ordered yesterday on the chemist of the Department of Agriculture, Mr. Godlove S. Orth of Indiana, Mr. Brutus T. Clay of Kentucky, Mr. Anthony L. Knapp of Illinois, Mr. John L. Dawson of Pennsylvania, and Mr. Frederick E. Woodbridge of Vermont.

HOUSE OF REPRESENTATIVES

Monday, March 21, 1864.

Mr. Orth, from the select committee on the chemist of the Department of Agriculture made the following

REPORT.

The select committee appointed for the purpose of inquiring into the facts connected with the special detail and absence from his department of Dr. C. M. Wetherill, the chemist of the Agricultural Department, beg leave to present the following report:

That soon after their appointment they entered upon the discharge of their duty and made diligent inquiry into the facts, by the examination of witnesses and the inspection of papers, and find that Dr. Wetherill was appointed such chemist on the 28th of July, 1862, and reported and entered upon the discharge of his duties on the 18th day of August of that year; that he was engaged in the discharge of such duties as were assigned to him from the date last aforesaid until the 4th day of April, 1863; that the stipulated salary for his services as such chemist was to be at the rate of fifteen hundred dollars per annum, which was paid to the 1st of April, 1863.

On the 4th day of April, 1863, Dr. Wetherill was detailed, for one month, by the President of the United States, for "special service, to report to Captain I. R. Diller, at Philadelphia;" and in pursuance thereof he proceeded to Philadelphia for the purpose of making scientific tests and experiments of a new article of gunpowder which said Captain Diller had brought to the attention of the government.

On the 2d day of May, 1863, and just before the expiration of the detail aforesaid, the chief clerk of the Department of Agriculture, at the suggestion and request of the Commissioner of that department, wrote to Dr. Wetherill that he should "remain at Philadelphia until notified to the contrary."

The committee are satisfied from the evidence before them that Dr. Wetherill, from the 4th day of April, 1863, was constantly and faithfully engaged in the discharge of the duty to which he had been assigned by the President, and subsequently by the Commissioner of the Agricultural Department, until about the 1st of October, 1863, at which

time the experiments in gunpowder were brought to a close, and Dr. Wetherill reported to his department, and was informed by the Commissioner that his services were no longer needed; that he received no compensation whatever for his services after the 1st day of April, 1863.

These are the facts as developed by our investigation, and we submit them to the consideration of the House. This House cannot reinstate him in his former position, but can provide for a compensation for his services while in the employ of the government.

We therefore report the accompanying bill and respectfully recommend its passage.

A BILL

For the relief of Dr. Charles M. Wetherill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to pay to Dr. C. M. Wetherill, the sum of seven hundred and fifty dollars, in full for his services as chemist of the Agricultural Department, out of any money in the treasury not otherwise appropriated.

The Bill for the relief of Dr. Wetherill was passed without opposition in the House and Senate and was signed by President Lincoln on July 2, 1864.

Wetherill's exoneration by Congress, although a distinct rebuke to the Commissioner of Agriculture, had no effect as to influencing the mind of Mr. Newton who, ignoring the requests for Wetherill's reinstatement, appointed Dr. Henri Erni his successor as chemist of the Department.

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**Skin Diseases That May Develop into Cancer.** Cancer is known to develop from various skin diseases. Some twenty of these were described by Dr. Joseph Jordan Eller of New York at the July meeting in Portland, Oregon, of the American Medical Association. Most common among these diseases that may develop into cancer are venereal disease, skin disease caused by overdoses of radium and X-ray, certain kinds of moles, skin troubles peculiar to certain occupations, scars, skin affections caused by handling arsenic or taking it internally, and various other conditions, especially those that become inflamed.

Black moles are always dangerous, particularly if located where they are subject to constant or even frequent irritation. If they give the slightest trouble they should be removed at once and completely, all at one time, Dr. Eller advised.

The occupations in which workers come into frequent contact with tar, which often causes cancer, are tar distillery, gas works stoking, chimney sweeping, benzene distillery and work with creosote, tar roads, paraffin, anthracene, coal oil, aniline dyes, and lamp black.

Cancer from arsenic is found among those who work with Paris green, wall-paper makers, smelters of various ores, furriers, tanners, farmers using arsenic sprays, and taxidermists.

Those who handle the heavy mineral oils, mule spinners, brewers, and X-ray and radium workers are others whose occupations favor the development of cancer.—*Science Service*

# THE RELATION OF CHEMISTRY TO HEALTH AND DISEASE*

JOHN R. HASLEM, INDIANA STATE NORMAL SCHOOL, TERRE HAUTE, INDIANA

There has been a great change in the purpose of chemical research since the beginning of the nineteenth century. The alchemists of earlier centuries had directed their efforts toward the transformation of the baser metals into gold and to the discovery of some drug capable of restoring broken health and prolonging life. These were not unworthy objects, but the energy was misspent because they did not understand the fundamental structure of matter and the cause and nature of disease. The search for the "Philosopher's Stone" has long since been abandoned, but the search to relieve human suffering has gone on unceasingly. Progress was slow at first, but the fires of this worthy cause were kept burning, waiting, as it were, for a master chemist to fan them into a flame which would lay bare the hidden mysteries of disease and its treatment. Such a chemist came, and the world will never be able to discharge its debt of gratitude to Pasteur, the French chemist, who, through a series of brilliant discoveries, found that many of our most dreaded diseases are caused by bacteria. No sooner had this genius discovered bacteria than he was preparing and purifying antitoxins and serums to treat or prevent the specific diseases, each of which he found to be caused by a definite microörganism. A few years prior to the time of this pioneer, Jenner had proved that a slight attack of some disease rendered the patient immune to that particular disease. Pasteur not only elaborated on this idea but also was so bold as to disprove the ancient theory of spontaneous generation. It is the purpose of this paper to follow the evolution of medical chemistry, so ably started by Pasteur and his coworkers.

JOHN R. HASLEM

Lister introduced the use of antiseptics, but most of these failed through lack of the proper concentration and purification; and instead of aiding in the cure of the disease, they only aggravated it by destroying the cells. Most of the modern successful antiseptics, used in combating diseases,

* Prize-winning normal-school and teachers' college essay, 1928–29.

have been discovered and brought to perfection in the chemical laboratories. In this list are iodine, bichloride of mercury, hydrogen peroxide, acridine yellow, lysol, hexyl resorcinol, and mercurochrome, the last of which was recently, at Johns Hopkins, injected into the blood to combat the dreaded *streptococcus haemolyticus*. During the World War, Carrel, an American surgeon, and Dakin, an English chemist, found that a solution of sodium hypochlorite kept wounds sterile. This antiseptic is now known as the Dakin-Carrel solution.

The cell is the main principle of life, and it can be fathomed to its depths only through the united efforts of the chemist and the histologist. Progress has already been made along this line through the introduction of the coal-tar dyes, which are used extensively in the preparation of antiseptics, drugs, and stains for the study of cell structures. At some future time, a cure for cancer may be found in the grimy coal-tar products extracted and synthesized by chemists. Methylene blue, carbol fuchsin, haemotoxylin, eosin, and gentian violet are especially useful in the staining processes. Cell life is very largely chemical in character since cell secretion, cell respiration, and cell nutrition are only different aspects of the same kind of molecular activity.

As an aid to the surgeon in diagnosis, the chemist has produced the valuable dye, phenolsulfonephthalein, which is used to test the functioning of the kidneys before major operations. Along with this kidney test is the Wassermann and Kahn test for syphilis; the sugar-tolerance test for the early stages of diabetes; the level of blood urea and creatinine tests for kidney disturbances, as well as the routine urinary analysis and blood diagnosis. Of no less importance is the Lichtheim coagulation test for the early stages of tuberculosis meningitis; the tests for hormone deficiencies; the amyl nitrite test for the presence of angina pectoris; the Widal test for typhoid; the Shick test for diphtheria; and the Dick test for scarlet fever.

Another phase of medicine which has been greatly improved by chemistry is that of anesthesia. Although nitrous oxide (laughing gas) was discovered in 1776 by Priestley, chloroform by Guthrie in 1831, and others centuries before, it was not until the middle of the nineteenth century that their value as anesthetics was made known. In 1885 Gadeke isolated cocaine, but it was not until 1884 that effective local anesthesia was accomplished by its use. Since then, chemists have studied the much involved structure of cocaine and have found that only a part of the molecule is effective in anesthesia. From this portion has been prepared eucaine and procaine which are used extensively by modern surgeons in spinal anesthesia. Butyn, related structurally to procaine and stovaine, has been derived from benzoic acid and is used in spinal anesthesia, as are also apothesine and psicaine. Stovaine became obsolete with the discovery of procaine by

Einhorn in Germany. Procaine, psicaine, apothesine, and butyn are all non-habit forming anesthetics and are better for infiltration anesthesia than for topical application. Ether, prepared by the dehydration of ethyl alcohol, is one of our most important anesthetic agents. Ethyl chloride is also being used either as a general or local anesthetic. As a "local," it is simply sprayed on the surface of the skin and its volatility causes a freezing of the tissues. The so-called sleeping powders are closely related to the anesthetics. Among the valuable soporifics are sulfonal, tetronal, trional, veronal-sodium, and luminal. The latter is used in nervous troubles such as epilepsy and St. Vitus dance. Luminal has almost replaced morphine although it also leads to habit formation. The insoluble local anesthetics, anesthesin, and butesin, are employed externally as dusting powders and ointments for the relief of pain due to denuded skin areas and internally for the relief of pain due to gastric ulcers.

One of the most valuable of the specific remedies is insulin which was discovered by F. G. Banting and C. H. Best, eminent chemists of Toronto. They extracted this hormone from the enzyme-free pancreas and it is now universally administered to those afflicted with diabetes. This dreadful disease is caused by the disorganization of the metabolic processes in the islets of Langerhans. As a result of their failure to function properly, sugar is lost through the kidneys. The stage of the disease may be ascertained by determining the sugar in the urine. Although insulin is not a cure for diabetes, it does to a certain degree restore health, which may be maintained through proper dieting. Thousands who formerly died with this disease now live out their natural lives.

The work of Fischer and Sherman stands out prominently in the field of dietetics because of their extensive research on the vitamins and the relation of vitamins to certain diseases. The work of these pioneers was soon followed by that of others. Dr. Funk of Poland found that scurvy could be cured by eating foods containing vitamin C which is found in fruits and vegetables. Takaki, a Japanese, made the discovery that beriberi is caused by the lack of vitamin B which is found in the husks of unpolished rice. Rickets was found to be due to the absence of vitamin A which is present in cod-liver oil. The disease pellagra has been fought with a diet of proteins and the so-called factor P-P, which has yet to be isolated and synthesized. The relation of factor P-P to the other nutritional factors and its distribution in foods is still undetermined. In this field, a fresh advance is almost certain.

Creative chemistry has certainly proved its worth in the contributions it has made to the persistent struggle to conquer the social diseases, syphilis and gonorrhea. For syphilis, mercury and potassium iodide were among the first remedies to be employed. With the use of the former, mercuric poisoning has been so frequent that chemists have constantly been seeking

a less toxic drug. Among those who worked to this end were Dr. Ehrlich and his associates. It has been found that organic forms of arsenic have low toxicity. One of these was prepared by the action of aniline on arsenic acid. Dr. Ehrlich began his work with the sodium salt of this acid and prepared a large number of its derivatives, in fact 606, before he found one with the desired properties. This particular derivation he named salvarsan because he thought it would be the salvation of mankind by destroying one of its greatest scourges. In chemistry, it is known as arsphenamine. This drug marks a great advance toward the complete suppression of this devastating disease. The gonococcus of Neisser, named after Albert Neisser, who isolated it in 1879, causes the horrible disease known as gonorrhea. For this infection, acriflavine is being used. It is a drug built up by chemists from the acridine yellow molecule. This is injected locally and administered internally as well.

The amoebic organism, which causes chronic *entemoeba histolytica*, has been successfully treated with emetine, one of the three alkaloids obtained from Ipecac root. This single-celled organism shrinks up and dies when emetine comes in contact with it.

The bacillus *Leprae*, which causes the dreadful and ancient disease known as leprosy, is overcome to a certain extent by a preparation made by digesting chaulmoogra oil in alcohol and a small quantity of sulfuric acid.

Epinephrine, commonly known as adrenalin, is extracted from the adrenal medulla. Its structure is definitely known and can be prepared synthetically. It has become an indispensable drug in medical practice. When administered with a local anesthetic, it prolongs the anesthesia by constricting the blood vessels, and thus decreases the chance for hemorrhage. When injected into the blood, it instantly relieves the difficult breathing of bronchial asthma. A deficiency of epinephrine in the suprarenal glands produces Addison's disease, which is characterized by the formation of tumors, feeble heart action, bronzed skin, and progressive anemia. The injection of adrenalin into the blood accelerates the heart action, diminishes the tumors, and increases the general tone of the body.

In 1852, Chatin pointed out that goiter was more prevalent in those districts where the soil lacked iodine. Baumann in 1895 recognized iodine as a hormone of the thyroid gland, and in 1916, E. C. Kendall of the Mayo Foundation isolated this hormone in crystalline form. He gave it the name of thyroxin. In 1927, Harington prepared a synthetic product which gave the same physiological effect as thyroxin. Iodine was first used in the treatment of goiter in 1820 by Coindet, a Geneva physician, and has since been used in the treatment of simple or edemic goiters which are caused by iodine deficiency. As yet, it has not been fully determined whether or not iodine relieves exophthalmic goiters.

The hormone of the anterior lobe of the pituitary gland has been found

by chemists to be very important in the body growth of the individual. A deficiency in secretion causes dwarfism while an over-secretion causes gigantism. Robertson prepared tethlin, a name given the fraction obtained from the *pars anterior* of ox pituitaries and alcohol, and the subsequent precipitation with dry ether. This product is claimed to give all the characteristic effects of the anterior lobe of the gland. Its complete value is not yet known. The hormone of the posterior lobe of the gland is known as pituitrin. Recently, however, Dr. Kamm of Detroit, according to the press, has separated pituitrin into two parts designated as alpha and beta. Alpha is used to reduce the suffering in childbirth and beta is expected to help many in surgical cases and in cases of severe burns, as well as to control the water in the body cells.

Chemotherapy is coming into its own by the extraction of such drugs as digitalis, ouabain, quinine, and quinidine, which have a very definite therapeutic action in several diseases. Chemists have found an antidote for the heavy metal poisonings in sodium thiosulfate, commonly called "hypo" by the photographer. When the system becomes poisoned by the concentration of mercury, lead, or arsenic in the kidneys, this salt renders these metals inert immediately when introduced into the body through the mouth or directly into the blood stream. In 1902, Blumenthal, a German, produced atoxyl, which he prepared by heating aniline and arsenic acid. This was used to treat sleeping sickness. Now the Bayer company of Germany has prepared a drug named Bayer 205 which is still more successful. The sodium salt of acetylsalicylic acid, known commercially as aspirin, is used for gout, rheumatism, and in cases of high fever.

Chemistry has made other contributions to medicine, such as theobromine and theophylline, which are being used daily in the treatment of edema, and are relieving thousands of chronic sufferers. Along with these is cinchophen and its derivative, novatophan; valuable drugs in the diagnosis and treatment of gout.

The use of poison powders, discovered by chemists, has almost obliterated malaria by the control of mosquito breeding. In the battle against the hookworm, the chemist has given relief to thousands by the introduction of thymol, carbon tetrachloride, and chenopodium.

The preparation of antitoxins from toxins by chemists is perhaps one of the greatest blessings of mankind. These antitoxins are built up in the bodies of various animals. For instance, the antitoxin for diphtheria is built up in the body of the horse; then after a certain period, it is removed, thoroughly purified, and then injected into the individual to safeguard him against the disease. In this way, scarlet fever and typhoid fever have already been mastered. Even common colds are being successfully treated by the use of serums and antitoxins.

Thus again and again has the medical profession in coöperation with the

chemists been able to prepare chemical substances of inestimable value in the prevention, diagnosis, and treatment of diseases. It will probably be through such coöperation that the three most dreaded diseases—pneumonia, tuberculosis, and cancer—may finally be wiped off the list of human afflictions by the discovery of a specific for each of these great scourges. Nor shall we reach the end until all the pathological conditions of the human body are understood and medical treatment is shifted from the curing of ailments over to the prevention of all diseases. The brilliant achievements of the past make us hope for results which a century ago would have seemed miraculous. We are prepared to expect the wildest dreams of today to become the realities of tomorrow.

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**Electron Experiments Support Quantum Theory.** By observing the way electrons, the particles of which material atoms are made, are scattered by molecules of a gas through which they are shot, Dr. Gaylor P. Harnwell, National Research fellow in physics at Princeton University, has furnished new evidence in support of the quantum theory. He reported his work to the American Philosophical Society recently in Philadelphia.

Previous experiments with rapidly moving particles of this kind from radium, as they passed through a gas, showed that they were scattered according to a law compatible with older physical theories. Dr. Harnwell used four gases, hydrogen, helium, neon, and nitrogen, and a beam of electrons moving more slowly than those from radium. The way they scattered bore no resemblance to that expected according to the older law, he said, but was quite in accord with the new quantum theory. This theory states that light and similar forms of radiation travel in separate bundles, rather than as trains of waves.—*Science Service*

# THE RELATION OF CHEMISTRY TO THE ENRICHMENT OF LIFE*

Joe Jones, State Teachers' College, Peru, Nebraska

Man's life today is that of a master who has many servants. He may call upon them, giving them tasks to do, and they will fulfil their duties well. Just so long as the management of these servants is kept well in hand will they work for good; but should their master put them to a wrong task, he must suffer harm—not by any fault of theirs, but through his own volition. There is one of these servants of man which he may either love or fear, according to his will, for the forces involving the enrichment of life or the destruction of life are bound within the destiny of the master, Man, and the servant, Chemistry.

Joe Jones

Chemistry has not always been so well understood as it now is. Its beginnings, however, are very old. The early Hindus, Greeks, and Arabs were chemists of divers sorts, quaintly mixing together all the three subjects of philosophy, alchemy, and astrology. The Chinese, it seems, were much more scientific in their method. We find record of a Chinese pharmacopeia compiled by one Shen-Nung in the year 2600 B. C. Well, then, perhaps chemistry is not so young after all! No—it cannot be, for it is vital to the existence of even a most puny and primitive civilization. It gives one of the prime requisites to fullness of life—that of an adequate and a comfortable physical environment.

The ways in which chemistry has aided our civilization to become rich and powerful are nearly numberless; to set them down completely would be to make a catalog. We might, for instance, trace the development of food preservation, beginning back before the time when the Roman salt merchants had a street all their own (the Via Salaria) and Nero's slaves brought snow from the Alps to cool wine for the Emperor, and coming down to the present means of electric refrigeration, or again, we might trace the long story of alloys, the romance of dyes, or the marvelous advances in textile chemistry. Paper would indeed unfold an interest-

* Prize-winning normal-school and teachers' college essay, 1928–29.

ing tale, as would the products rubber, stainless steel, and movie films. Coal tar could tell us more stories than Old Uncle Remus and his Tar Baby ever dreamed about!

The strict term "enrichment of life," however, embraces a lifting out of the commonplace into the realm of the cultural.

Chemistry, as a physical force, has no peer; but that servant must also be an intellectual force and show men what to make of their surroundings in order that they may obtain a richer existence.

Science has given to man more time to be at ease—more respite in his never-ending battle with the forces of nature. Again, it has prolonged his span of life; not by mere years, but by entire decades. To cast man into a sudden inheritance of leisure without providing him means for using it would be too hard, and science does not intend that it shall be so. It has bestowed rich gifts of culture along with the bequest of time. Man must use them in the best way he can, for science can do no more.

Since chemistry is definitely so many-sided the task of treating it as a compact whole is a trifle cumbersome. In such a discussion, therefore, it will be necessarily treated in such a way that the form will assume a philosophical aspect. If we were to begin enumerating all the ways chemistry benefits mankind, we might as well try to count the stars. In all its myriad branchings, however, there is an intertwining—a suture, as it were—which makes the part coherent with the whole.

The grouping of many activities and industries about a single element and its compounds is a very common situation today. The element silicon, Si (Latin silex, the flinty element), lends itself admirably to a type discussion of this tendency, for the cultural value of silicon is great. Man has silicon in his body, and has long been building out of it houses of bricks for his body to dwell in. Thus, architecture, one of the noblest of the arts, has its very foundations upon this element! Glassware, always a mark of culture, was early introduced into the Orient and Egypt. Many of the ancient works in glass rival the best ones wrought in modern times. The uses of glass and glassware today are thousands of thousands-fold, and only just now the astronomers, seeking to build a greater telescope than ever before, are centering their attention upon silicon. This element builds the foundations of a structure with its bricks, is contained in the concrete poured into the forms, and, contributing even to the steelwork, finally finishes up the job in terra-cotta. And thither we go, with a chemical element leading us by the nose clear over into the fields of architecture, astronomy, and engineering! Chemical elements simply do not and will not stay at home—they work for everybody.

In the more abstract realm, chemistry has always been a companion to philosophy, as have, indeed, all sciences. Alchemy was the result of misapplied philosophy; the phlogiston theory was another "hard nut to

crack." Early thinkers, however—men such as Leonardo da Vinci (1452–1571), Robert Boyle (1627–1691), and Lavoisier (1743–1794)—founded the true school of scientific philosophy, the outgrowth of which is the scientific method. In the words of Boyle, "There is no other way to seek knowledge than by making varied research upon the things which are found in nature."[1] This struck the diapason chord of truth, and its tones swell louder and resound more clearly as the wheels of time move on.

We come, then, to the contributions of chemistry to the intellect, dating from the early fields of philosophy and companion branches. In the realm of high thought, chemistry has done a titanic service. The mind which is truly broad must hold in its scope not only the outward manifestations of infinity—the eternal suns and stars—but as big a concept of infinity turned downward into the intricacies of the yet more wonderful world of the microscopic and ultramicroscopic forms. To some, these revelations unfolded come as a thunderclap; to none should they in any small portion deny the never-ending teleology of that Power beyond our ken.

A great stirring up of minds has come about in recent years through the changes chemistry has brought to ideas about the construction of matter.

The conception of matter which chemistry holds forth is one of absolute unity, not only in a world so small as our own, but reaching out with the spectroscope to stars far beyond those the eye can see. In all of them like elements are found. The order of the atom and of the universe is obedience to regulated law; their law is that of observance to rigid order. In the evolution of matter there is no death: integration and disintegration are being carried on concurrently by mysterious rays. On every side the spectroscope reveals evolution at work.

Taking the mind still further into the depths of truth-seeking, there comes now, though darkly, the belief that there is but one entity in nature—that of energy. Matter, it seems, is considered to be incarnated energy; from this comes the interconvertibility of energy and matter. Can minds be passive when stirred with thoughts like these?

How often it is claimed that science is the enemy of religion and the harbinger of doubt! True science can be neither; neither will true religion term it such. Each will agree with Fiske in that "Science is the handmaid of religion." In all the froth and foment of controversy, men seem to have gone no deeper than to skim the dross from the crucible of each. The thinker is not interested in slag. In the metallurgy of the mind science and religion are not two separate metals, but an alloy—stronger, more durable, and more beautiful than either of the metals which compose it.

[1] Arrhenius, Svante, "Chemistry in Modern Life," D. Van Nostrand Co., New York, p. 19, 1925.

The ethical principles of the scientific man, while they may seem sometimes to be severe, are some of the highest to which mankind may attain. It is the realization that he is doing his work in the service of mankind which brings such a high-minded code to the scientist. True, there are many pseudo-scientists to whom ethics mean little or nothing—these are known by their fruits.

It must be realized (and a glorious realization it is!) that man's environment can be only what he makes it. To provide his physical needs, chemistry will work well; but there is a far greater service than this to be performed. Herein should be the burden of its message in days to come. To nurture the body is a noble service, and were that the only benefit brought by this servant of man, he would be eternally bound in gratitude. In order, however, that man may attain more to richness and fullness of life, the mind must be made stronger and the soul more beautiful. Thus comes yet the greatest capacity of chemistry—the rôle of teacher.

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**Insect Pests Resist Deadliest Poison Gas.** Insects are better able than men to resist the fumes of hydrocyanic acid, deadliest of all known gases. This was brought out in reports by a number of scientists before the California meeting of the American Association of Economic Entomologists.

Hydrocyanic acid has frequently been proposed as a possible war gas. A very low concentration of it will kill human beings almost instantaneously, and no known gas mask could stop it. It cannot be used for military purposes, however, because of its extreme volatility, which dissipates it very rapidly when it is released in the open air. It would be effective only in closed spaces, such as dugouts or the hold of a warship. It has, however, come to be very widely used for killing scale insects and other pests in orchards, being released under tents that are thrown over the trees to hold it down.

There have been claims that strains of insects are being evolved in California that can stand increasingly heavy doses of the deadly vapor. These received some substantiation from G. P. Gray and A. F. Kirkpatrick, of Azusa, Calif. They established black scale insects from so-called resistant and non-resistant districts on potted seedling orange trees and simultaneously fumigated them under the same covering. There was a much greater percentage of survivors among the scale insects from the reputedly resistant districts.

If certain species of scale insects get just a faint whiff of hydrocyanic acid it "knocks them stupid," but in this condition of stupor they can survive a gassing that would otherwise kill them very quickly. This was brought out in experiments reported by Mr. Gray and Mr. Kirkpatrick. This "protective stupor" may be achieved by insects in remote parts of the covering tent, or even by insects on neighboring trees reached by escaping whiffs of the gas. It was recommended that some sort of circulating fan be used to make the gas reach all parts of the tree in full concentration at once.

Fumigating flower bulbs to rid them of insects may have other beneficial effects, according to the observations of C. F. Doucette and F. J. Spruyt of Sumner, Wash. They found that narcissus bulbs exposed to cyanide fumes blossomed from two to six days earlier than unfumigated control bulbs.—*Science Service*

# FIXATION OF NITROGEN*

RALPH D. SPEARS, STATE TEACHERS' COLLEGE, SLIPPERY ROCK, PENNSYLVANIA

Ye rigid Ploughman. Bear in mind
Your labor is for future years.
Advance! Spare not; nor look behind.
Plow deep and straight with all your powers.

Ever since the race of man began, food has been the vital question. The early cave men who were the seeds of civilization existed only because they were able to overcome the disintegrating forces of nature, disease, wild animals, and their weaker fellowmen in their quest for food. As man advanced, his food problem became more complex until he finally turned to the cultivation of the soil in order to produce plants that would help sustain him. Plants became the food of the entire animal kingdom. It is an established fact that all living things, whether of flesh or fiber, must have food in order to promote growth and support life. Plants, as the source of that food, must receive nourishment, too, in order that they may not only meet the constant demand, but go even beyond that to provide for future use.

RALPH D. SPEARS

There must be certain chemical elements within reach of the roots of the plant for its own sustenance. More than fifteen elements are necessary but, ordinarily, the supply is great enough for the plant's demands, except in the case of nitrogen, potassium, and phosphorus. These elements are fatal to plants in elementary form; and in order that they may be absorbed, they must be fixed in neutral salts. For the last three hundred years, the American people have been reaping their harvests from virgin soil, but now that all our land is occupied, we must learn, as others before us have learned, how to keep up the supply of plant food which was so plentiful in the new soil. Not until this deficiency in the soil has been heeded, will America be able to keep her place with other agricultural countries of the world.

Just as food is essential in man's existence, nitrogen is indispensable in the life of a plant. The necessity for it has long been known. Early

* Prize-winning normal-school and teachers' college essay, 1928–29.

chemists knew it to be a part of most animal and vegetable matter and to be necessary for life. It was discovered in 1772, but until 1900, very little use had been made of the discovery. Nitrogen is found abundantly in the air, but it will scarcely ever unite with other elements, and very few plants are able to use free nitrogen. As time went on, cultivated plant life so depleted the supply of nitrogen in the soil, that its restoration became a vital problem for the agriculturist.

But why should the soil be so impoverished for nitrogen, when the earth is being constantly bathed in an atmosphere four-fifths of which is composed of nitrogen. It is estimated that there are 20,000,000 tons to the square mile of nitrogen pressing down upon the earth. It might seem impossible that there should be a shortage of nitrogen in the earth's crust. The difficulty is that it will not combine readily with other elements. All growing plants use nitrogen and when the plant is grown and used for food, the amount of nitrogen removed from the soil is enormous. A good wheat crop removes nearly 50 pounds per acre. It would require 200,000,000 tons of ordinary mixed fertilizer to replace the amount extracted from all the land cultivated in the United States each year.

After many vain attempts to combine nitrogen with other elements, Sir William Crookes, a well-known British chemist, made the following statement before the British Association for the Advancement of Science, in 1898: "The fixation of nitrogen is vital to the progress of civilized humanity. The fixation of nitrogen is a question of the not far-distant future. Unless we can class it among certainties to come, the Caucasian race will cease to be the foremost in the world, and will be squeezed out of existence by races to whom wheaten bread is not the staff of life." The years of plenty were passing. The supply of wheat, which is the staple foodstuff of the Western people, would soon be insufficient to provide for the needs of a growing population. Unless the yield of the soil could be greatly increased by intensive cultivation, famine would literally stare us in the face, and intensive cultivation would exhaust all the known sources of nitrogen in a few years. Sir William Crookes' warning was timely, for nothing was being done to increase the supply of nitrogen, and famine of the soil was inevitable.

Nitrogen is used, not only to enrich the soil, but, also, in the manufacture of dynamite, gunpowder, dyes, and other products. Enough nitrogen was thrown away in one decisive battle of the World War to save India from famine. The population was not lessened to any great extent, but the soil was robbed of its power to support the population.

"Plants rise on the stepping stones of their dead selves to higher things." Each new plant lives on the humus made by the old plant and what it is able to add from the air and sunshine. As soon as a tree or leaf falls, myriads of bacteria and fungi break it up into its component parts called

humus. Other bacteria change the nitrogen in the humus to ammonia; still others to nitrites; and a final group converts nitrites to nitrates. These phenomena help to replace the amount of nitrogen extracted but do not increase the supply.

The methods of agriculture used by early man were sound and productive. He learned to sow pea-like plants every third year and to plow them under to increase the productivity of the soil. Animal manure has been used for ages as a fertilizer. It contains nitrogen, phosphorus, and potash, and is a means of returning part of the nitrogen taken from the soil by the plant. The fertilizers known to early farmers were not sufficient, though, to replace and increase the supply of food derived from the soil.

The Indian, long before the white man came to America, found that he could enrich the soil around his corn plant by putting a fish in with the seed. He knew that it would increase his corn yield. The early settlers soon acquired the same method and, later, learned to use other material as the nitrogen-giving element.

Fixation of nitrogen is the process of converting free nitrogen into nitrogen compounds. Certain bacteria which are able to fix nitrogen have made agriculture and all plant life possible. Nitrogen can be obtained through leguminous crops but it is not believed to be much cheaper to secure it thus than to use commercial fertilizer. However, the fact remains that some day the farmer may be able to control the bacterial life of his soil so as to insure an abundant supply of nitrogen.

When fertilizer was discovered, nitrogen was one of its constituents. One source of supply was found in the rich deposits of guano on the Chincho Islands off the coast of Peru. Here, millions of penguins and pelicans had lived for centuries, piling up their excrements, dead birds, and fish to the depth of 120 feet. This deposit was rich in nitrogen but the supply was soon exhausted by the removal of a billion dollars worth of the guano. In the mainland of Peru and Chile, there were similar accumulations of guano, deposited as sodium nitrate. The origin of these beds is not known, but they occur in patches four to twelve feet deep. This Chilean nitrate has been used as a source of nitrogen for soil purposes for nearly one hundred years. In 1830, only a few thousand tons were shipped, but in 1913, two million tons were exported. Altogether, 35,000,000 tons have been taken from this source in the last twenty-five years. Germany nearly doubled her yield of wheat per acre by using Chilean saltpeter. The chief drawback has been that this product is rather expensive. However, other successful methods of obtaining nitrogen are now setting up rivalry which will result in a lowering in price of the Chilean saltpeter. There has been a lot of discussion as to how long this supply will last. The promoters claim that it will last a thousand years, but government inspectors,

not nearly so optimistic as the promoters, assure us that the supply will not be exhausted, at least, for one hundred years.

The amount of nitrogen received from coal, peat, silt, and lignite is very important. When coal is heated in ovens for making coke, a large amount of ammonia comes off. It is caught in sulfuric acid and used as ammonium sulfate. For years this product had been escaping into the air, and we were losing 700,000 tons of ammonium salts per year. The ovens have been changed now, and in 1919, 1,466,000 tons of ammonium sulfate were secured from the distillation of coal. There are peat moors in New England and in Asia which supply a large amount of nitrogen. There are also 12,000 tons furnished by blast furnaces every year. While this supply is valuable, it is inadequate for the demand.

Two smaller sources of this valuable element are waste products and precipitation. There is nitrogen in such waste products as cotton seed meal, meat packers' scraps, fish scraps, dried blood, and tobacco stems. These are called organic ammoniates. However, at this time, many of them are being used in stock feed rather than for soil purposes. The second source of a small supply is the amount received by precipitation. About five pounds per acre of fixed nitrogen is carried into the soil every year by rain and snow.

Nature has provided to some extent for the soil's need with a nitrogen cycle. (1) Free nitrogen enters into combination by the aid of bacteria or by electric discharges. (2) This compound, then, enters into the plant as nitrate. (3) The nitrates changed into proteins are transferred from plant to animal. (4) They either remain in the soil in accumulations, or are returned to the air as free nitrogen.

It would seem that the supply of nitrogen from the sources already mentioned should be sufficient; but when we consider that, after taking account of the amount returned by manures, leguminous crops, precipitation, and commercial fertilizer, the loss of nitrogen from all lands cultivated in the United States is nearly 4,000,000 tons, we are impressed, then, with the need of a much greater supply. Our population is increasing; therefore, the production must increase. The area of our country is limited; so the solution must come from a greater production per acre. Beside the loss of nitrogen in plant life, there is constant loss in cultivation through leaching and oxidation. Experience has shown that the world's total consumption of nitrogen compounds, in the last few decades, has doubled every ten years. For thirty years, the atmosphere has been recognized as the only source capable of meeting the demand. Many investigations have been made along this line.

At the beginning of the World War, the United States felt the need of more nitrogen and Congress made $20,000,000 available, in 1926, for investigation of various methods for the production of nitrate to be used

for munitions of war and in the manufacture of fertilizers. Germany, alone, knew the latest and cheapest process of fixing nitrogen. It is doubtful if they would have attempted the war without this nitrogen-fixing secret; and it is certain that, without it, they would not have been able to have carried it on as long as they did.

Previous to this time, chemists used two methods in fixing nitrogen. The arc process consists of passing air through an electric arc and dissolving in water the small amounts of nitric oxide thus formed to produce nitric acid. This process made use of raw material—air and water; the labor cost was low but the power was very expensive. For this reason, there are very few arc plants in the world at this time. Norway is the only place where the system is used to any great extent. In 1927, there were only seven arc plants in the world, with a capacity of 46,200 tons of nitric acid. The second process, known to us before the war, is the cyanamide method. It consists of heating calcium carbide with nitrogen in an electric furnace. The cyanamide is applied directly to the land as fertilizer, and upon exposure to water at ordinary temperature, it evolves ammonia which, under the action of nitrifying bacteria, is converted into compounds of nitrogen, which are readily absorbed by growing plants. The objection to the cyanamide process was that the power was too expensive. This method is not used in the United States at all now. In 1927, there were 28 cyanamide plants in the world, with a capacity of 313,500 tons.

The method for fixing atmospheric nitrogen, which Germany employed during the war, has since been carried out in the United States on a large scale. It is known as the Haber process by which nitrogen and hydrogen are used and the result is ammonia. The agent used is some rare metal, such as platinum, uranium, or osmium, which acts catalytically to decompose the elemental molecules and recombine the atoms in a new form. The ammonia produced is changed into nitric acid. This method is by far the most important because of the ease of manipulation and the relative cheapness of the necessary materials. It is one of the processes originally designed for use at Muscle Shoals, Alabama, where the plant erected during the war is the largest undertaking of this kind. Great influence is being used now to reopen this plant for soil fertilization purposes.

A cheap source of nitrogen would go a long way in solving some of the farmer's economic problems and would enable him to reduce his cost of production greatly. When nitrogen is purchased in commercial fertilizer, it is the most expensive plant food present, and its use is frequently prevented because the value of the increased crop is not sufficient to pay the cost of the fertilizer and also yield a profit to the farmer.

In the last analysis, probably all of the nitrogen from the various sources came from the air, for it is an element which easily escapes from chemical

combinations. Once free, it is only with difficulty that it can be made to combine with anything else. The problem, then, of fixing nitrogen has required much research and investigation, but a knowledge of its value to the soil and the liberal use of it will repay all time and effort spent upon the project. "It has been truly said that in the present state of civilization, a nation lacking an adequate supply of nitrogen can be neither great in peace nor in war."

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**Volcanoes Said to Put Salt in Ocean.** The 485 known volcanoes of the world, discharging every year more than a hundred million tons of hydrochloric acid, supply the chlorine that keeps the ocean salty. This is the opinion of Dr. Thomas A. Jaggar, director of the Hawaiian Volcano Observatory at Honolulu. Even though the amount of hydrochloric acid gas in steam from volcanoes is almost negligible, the ceaseless emission of this steam puts the gas into the air, and thence into the rain. With the average rainfall of about 40 inches a year the world over, rain water would only need to contain about one part of chlorine in five million to supply the ocean's needs. This chlorine unites with the sodium brought into the sea by the rivers and forms sodium chloride, or common salt.

The volcanoes of the Katmai area in Alaska alone supply about one per cent of the hundred million tons of hydrochloric acid gas needed. Even the great Hawaiian volcano Kilauea, the steam of which contains only a trace of the gas, contributed something like thirty thousand tons a year, Dr. Jaggar said. And in addition there are many unknown submarine volcanoes, each of which is doing its bit.

Dr. Jaggar also explained the presence of calcium carbonate, which is the same as marble, in sea water.

"This is secreted from the water in the body of *globigerina*, a tiny organism ceaselessly dying and depositing billions of skeletons that make chalk on the ocean bottom. Locally the ocean floor is built up a foot per annum. Ten thousand years would shoal the ocean, but there have been millions of years, and the ocean is still deep.

"But though *globigerina* is everywhere in the upper waters, two-thirds of the seabottom has no chalk. What could account for chalk banks being absent? The chalky bottoms are where the ocean is not so deep. It was found by Dr. J. Stanley Gardiner, professor of zoölogy at Cambridge University, that where the ocean is more than two and a half miles deep, where the pressure approaches three tons per square inch, sea water can readily dissolve the chalk skeletons. And so, with the circulation of the oceans the lime salts are brought back and secreted over again by the live organisms."—*Science Service*

# CHEMISTRY IN RELATION TO NATIONAL DEFENSE*

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In its short existence as a real science, chemistry has manifested itself in all fields of human endeavor; it has revolutionized human civilization, and opened up great fields in which the chemist can expend his energy both in times of peace and in times of war. Already, chemistry has come to be a tremendous force and the heights to which it may raise our civilization in the future can hardly be imagined. From the innumerable branches of this invaluable science, I shall choose one in connection with which I hope to set forth a few of the reasons why chemistry has played and will play such an important part in the history of the world. Therefore, while the great World War with its multitudes of horrors is still fresh in our minds, and since the results which it produced are so outstanding today, I think that chemistry in its relation to war will be a pertinent and timely subject.

ELVERE CONNER

Through all the ages, war has been the contest of the resources of one nation with those of another, and the nation with the most effective resources at hand was the victor. Long ago, hand-to-hand combats, brilliant artifices, and the force of human strength, served to settle affairs among enemies. Even then, the battle ax, sword, projectile, and cross-bow, used in turn by the ancients, depended upon chemistry for their materials. During the past twenty-three hundred years, history tells us that gas was used at various times. Probably the first records are those of the Chinese and later the Japanese whose odorous gases and finely ground pepper were the forerunners of the modern lachrymatory gases. Then history tells us that gas was used by the Athenians and the Spartans as early as 431 B. C., and "Greek Fire," used against the Saracens in 673 A. D., was in turn employed against the Christians during the Crusades. Later on, the British used sulfur and coke during the Crimean War, but decided that this means of combat was too horrible to be honorable. Therefore, they did away with this process of warfare, and left chemical warfare to be introduced by the Yankees during the

* Prize-winning normal-school and teachers' college essay, 1928–29.

Civil War, when they shelled the city of Charleston in 1863. Such means of warfare have not been without protest on the grounds of cowardice and inhumanity, but so effective have they been that it is impossible to prevent their use in some way or another.

The Peace Conference at The Hague in 1889 condemned the use of poisonous gas as against the laws of civilization, and the leading powers of Europe signed an agreement against it. Germany, however, in 1915, demonstrated that gases could be used in ways which did not violate the treaty in words, although they did misinterpret the spirit, and from that time on, gas came more into use. While the chemist had a part in the perfection of ordnance and in obtaining such precision in the rate of burning powder as to make possible the introduction of new military tactics, it remained for the use of gases, such as chlorine and bromine, recognized as chemical substances, to truly introduce the term "poisonous gas" and the designation "Chemical Warfare." Reference must be made to the poison gases which developed from the forms of gases mentioned previously as used by the ancients, and which did such dreadful havoc on the battle fields of France. When Germany first introduced her corrosive gases, chlorine and bromine, the ingenuity of the chemists all over the world was immediately taxed to develop this deadly warfare. Here again was an emergency which called forth the minds of the chemists to quickly devise ways and means of large scale preparation, and of shipping and loading such dangerous substances. Moreover, mustard gas and arsenic compounds were ingeniously developed, along with many other fatal artifices.

It is evident that if the war had continued longer the powers engaged would have drenched each other in poisonous gases, but by the sudden close in 1918 the world was saved from the destruction which would have been the inevitable result. Instantaneously the use of gas called for new types of absorbents with which to perfect the gas masks, and this call was met by the chemists who employed their skill in mixing charcoal with soda lime and other absorbent chemicals to place in the breathing tanks of the gas masks and thus save the men on the battle front.

Then tear gases, which render the subject unfit for military duties, and sneeze gases, which bring on violent fits of sneezing, were employed. In addition there should be mentioned the safe non-toxic screen smokes ejected from airplane, thrown by hand or fired from rifles, and smoke candles. These materials were used to blind the enemy by reducing visibility, to obscure troops, to render battleships inactive, and to protect troops from fire. The greatest use of weapons of chemical warfare is in the fact that gas will penetrate protected positions and drive out the enemy from hiding places which cannot be reached by shell.

The chief requisite of poisonous gases are nitrates, potash, and phosphates, and since these are chiefly found in foreign lands, the American

chemist again is faced with the problem of accessibility and large-scale economical production which could be practical both in peace and in war.

As a result of chemical inventive genius gas tactics became the main strength of the war and gas became a standard weapon for certain purposes. Shell gas was used for the neutralization of batteries, roads, and areas, and cloud gas was used to produce untold tragedies. The former which was made from brominated and chlorinated organic compounds and from salts of dianisidine, caused intense irritation and served to check the armies until Germany realized her need of still more effective weapons and manufactured lachrymators, crude brominated xylene or brominated ketones, which caused temporary blindness. These gases kept the troops out of the places where the gas penetrated and thus frustrated a great many plans. In the meanwhile, Germany had been seeking to regain the cloud gas initiative. Consequently, a mixture of phosgene and chlorine in a very high concentration was introduced as a cloud gas. Many casualties in the form of sudden collapses among the soldiers resulted and oftentimes fatal effects were produced. Green Cross, containing diphosgene, Yellow Cross, containing mustard gas, and Blue Cross, containing diphenyl-chlorarsine, were successfully used one after another. The mustard gas produced severe blisterings and skin wounds, while Blue Cross was a deliberate attempt to pierce the respirator. Later particulate clouds, combined smoke and lethal gases, were introduced with the object of piercing all respirators whatsoever, but, fortunately for the allies, these objectives were never attained. There are twenty-five or more gases which Germany used and from the few mentioned here we see the importance of protective preparedness and manufacturing capacity in order that a country might gain the advantage in the use of gases.

This gradual introduction of chemistry into war has taken chivalry out of warfare—brains have taken the place of brawn; war is fought out in laboratories and in chemists' minds, and the glory which war brings to its heroes is fundamentally due to the chemists, for it was the latter who discovered the high explosives and the new steel to withstand the force of such explosives. Thus, when the World War broke out we scarcely realized that a new era of modern warfare had begun and that chemistry was to play such an important part in the conflict. However, the results of the war have awakened a deep interest in the leaders of our nation. They have come to realize that the development of our civilization is a result of chemical research, and that the future of our country and the maintenance of our national defense depends upon the further development of chemistry. Thus it is obvious that the victories of future wars will be awarded those countries whose chemical monopolies and genius surpass all others. It is our duty, therefore, to awaken to the utmost the interest of our people in the value of chemistry, and to judiciously expend our natural

resources, for those of our country are practically inexhaustible. Our resources are greater than those of any other great power; the ingenuity of our chemists is likewise unsurpassed, and our merchant marine can compete with that of any other country in the supremacy for world trade.

Until recently our interest in chemical development has been insufficient. We have allowed other nations to profit by the indifference of our public to the products of chemical development, but there is still need for our nation to realize more fully its situation and to save herself by such legislation so as to render another horrible conflict unnecessary. This idea can be carried out through the development of industries which are valuable assets to our country in time of peace and which can easily be made into valuable implements of war in case of emergency. Such industries will attract the genius of our chemists, and through our own resources make our country independent of other nations and therefore break up any monopoly which other nations hold.

Today the manufacture of modern explosives is essentially a chemical industry founded upon the most careful research and supervised in all departments by highly trained and experienced technical men. Picric acid and guncotton form the basis of modern smokeless powder and dynamite, while T. N. T. and other nitrated bodies came into their greatest use during the World War. Prior to that smokeless powder took first place among military explosives. Amotol is another World War product and benzine, a by-product of the coke and gas industry, is also an important raw material. In the manufacture of these explosives there are many difficult chemical problems—prevention against corrosion, safeguarding against hazards, to say nothing of the manufacture itself. Furthermore, without fixed nitrogen in great abundance nations could not wage war upon one another under modern conditions. Gunpowder is probably the first recorded use of chemical substances mixed together for military explosives, and ever since it replaced the bow and arrow this form of nitrogen has been used in the making of explosives. Fixed nitrogen is used because it has an extraordinary power to break down into new combinations, absorbing and giving out enormous energy as in the case of high explosives. It is this underlying chemical fact that has been responsible for the dreadful slaughter and destruction of recent wars. Dynamite, guncotton, picric acid, and nitro gelatin are all nitrogen-combined substances, fixed so that they will not explode prematurely. Picric acid, one of the most deadly of high explosives, was made into tons of mixtures and shot off on the European battlefields. When these mixtures are shattered into elements, large quantities of hot nitrogen, hydrogen, and oxygen atoms are instantly set free, seeking to expand and satisfy their various affinities. Death and destruction are the consequences when such destroying forces are scattered.

Chemistry has made other contributions to the art of war beside those

comprised in the coal-tar industries and nitrogen fixation. The World War was attended by the discovery and introduction of more new theories, facts, innovations, and mechanical devices than have ever before been produced in any era of history. There is work for the physiological chemist, the pharmacologist, and others who must determine the chemical reaction of poison gases when they reach the body, so that they may design methods of treatment. Some of the gases penetrate the skin, are absorbed by the blood, and cause serious trouble. Consequently, man must use his intelligence in self-defense. And the fact that knowledge of the gases and smokes enables man to devise efficient methods for self-defense, which he cannot do in the case of shell and shot, gives him ample opportunity for self-protection in the case of chemical warfare.

One of the greatest results of the recent conflict is progress in aviation. It is obvious that new alloys, or their new use, is involved in obtaining the utmost horsepower with light weight in airplane engines and that the lightest metals consistent with strength are needed not only in airplanes but also in dirigibles. Chemistry made an important contribution to the propellors of aircraft by providing an adhesive, waterproof, dependable, and strong varnish with which could be built up the laminated wood of the propellors. Then it has also suggested how these might be protected from the erosion caused by the rapidly passing air. Special types of chemically controlled fuels are demanded. The question of balloon fabric and what to put in the bag is also of great importance. Chemistry began research to learn how to get helium in sufficient quantities from natural gas wells in Texas and Oklahoma for military purposes, and this production of helium has brought about a condition of constantly reducing cost. Aviation required the crucial test of the World War to stabilize it. Luckily, however, war is not the only use in which aviation is important, for it promises to become an important means of commercial transit.

The importance of chemistry in its relation to war becomes emphasized in the necessity to increase food supplies and production, to find domestic materials to replace those formerly imported, and to conduct industry generally at a high efficiency and at great pressure. Under the stimulus of rising prices, it became economical to recover many things from wastes which had been of no commercial value in normal times. Synthetic organic chemistry was called upon to do in five or six years what those specialists in other countries had done in a generation. There had to be antiseptics, anesthetics, sedatives, and germicides in unprecedented quantities and of the newest synthetic types. These things, however, are needed also at other times and go to show that chemistry works just as effectively in peace as in war; but its relation to national defense in the instances I have cited merely serves to emphasize its importance as a fundamental science, and to show the vast importance of our nation's awakening to the fact that the chemists

who are so often blamed for the horrors of war are inevitably drawn into the conflict through the results of their peace-time activities. Nevertheless, the abundance of our national resources still call the chemist and when America realizes altogether the absolute necessity of her dependence on chemistry for national defense, and develops industries which will serve her in peace as well as in war, she can be assured, if the necessity again arises, that the products of peace will reap victories in war.

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**Dried Fruits Prevent Scurvy.** Dried fruits which have been treated with sulfur dioxide gas maintain their vitamin C content, and therefore their ability to prevent scurvy, according to a study to be reported in the *Journal of Biological Chemistry*, by Agnes Fay Morgan and Anna Field of the University of California, Berkeley. The same fruits dried and not subjected to the sulfur dioxide treatment lose their vitamin value.

Fruits and vegetables are known to contain vitamin C, and it has been considered that these foods must be fresh when used to prevent scurvy. Since the danger of scurvy is greatest under circumstances where an adequate supply of fresh vegetables and fruits is most difficult to obtain, much interest has been shown in the effect of methods of preservation upon the vitamin C content of foods. Numerous studies have been made upon citrus fruit juices, cabbage, milk, potatoes, and tomatoes.

Apparently the more acid foods, such as citrus fruits and tomatoes, are not only more richly endowed with vitamin C, but are also better able to resist destruction of this vitamin by drying or processing.

Because of the inconsistency in previously reported work by other experimenters, and because of the economic importance of the commonly used dried fruits, the experimenters used peaches as the basis for their work.

Fresh, completely ripe peaches were used. They were picked, pitted, and ground in a food chopper. Some of the batch was sun-dried and some dried in dehydrators. Part of the dried batch was submitted to the action of sulfur dioxide over night. Then feeding experiments were made using guinea pigs. It was found that the sulfured fruit retains the full vitamin C content of the fresh fruit, but the unsulfured dry fruit retained no detectable amount of this vitamin. The sulfured, dried peaches were found to rank with orange juice, raw tomatoes, and other highly potent antiscorbutic foods.—*Science Service*

# THE RELATION OF CHEMISTRY TO THE HOME*

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Our complex modern civilization is a direct result of the application of chemistry to industry and everyday life. To many, this statement means nothing, yet, if they would only investigate the origin of hundreds of things with which they are always in contact, they would know its truth. Beside revolutionizing industry, improving agriculture, checkmating disease, and strengthening the national defense, chemistry has blessed the home with comfort, beauty, and economy to a degree undreamed of a few years ago. The home, being the foundation of society and giving the child its first and lasting impressions, should radiate an atmosphere of refinement and culture. Chemistry is always working to this end, and is absolutely necessary to make it possible.

HENRY L. PRICHARD

As Cicero once remarked, "There is no place more delightful than one's own fireside." As it was then, so it is now. Yet how different is the modern home from the dwellings of the Roman people. Although not dating back to Cicero's age, a brief description is given of the Kentucky pioneer home of a bare hundred years ago. A cabin constructed of logs, chinked with mud, and roofed with clapboards provided a shelter. Puncheon floors were common. An open log fire was the source of heat and light. All furnishings were crudely hand-made. The cooking was done over an open fire with metal implements and utensils that were rare. Textiles were of home production. Soap was made of grease and wood ash. Water was drawn from an open well by means of a sweep. Fire was obtained from a tinder-box. Although many individual operations now called chemical were practised, it is apparent that chemistry had no conscious part in this home. But, as chemistry is in reality a recent science, and, as everything in the modern home has a chemical history, the following paragraphs will depict the dependency of the home on chemistry and the true relationship existing between them.

* Prize-winning normal-school and teachers' college essay, 1928–29.

First, we shall consider the shelter. A durable and comfortable building is essential for the existence of a well-regulated family. If a person should observe the construction of the foundations, he would notice a gray powder being mixed with sand, gravel, and water. The mixture is then poured into forms and allowed to dry, producing a grayish artificial stone. The gray powder used is Portland cement, which binds the sand and gravel. This cement is a product on which hundreds of years of research were spent, being perfected by the chemists of our era.

The history of cementing materials began with the Assyrians, Babylonians, Egyptians, and Greeks. Following rather closely the Grecian method of producing cement of lime, sand, and pozzolana, the Romans made a cement that resisted the action of fresh and salt water. These pozzolana cements were somewhat similar to our present-day Portland cements. However, the modern cement industry began in 1756, when John Smeaton, an Englishman, produced a mortar that would harden under water. After further experimenting, Joseph Aspdin patented an improved Portland cement, the name Portland coming from the fact that when hardened, it resembled the famous Portland building stone. When the chemist analyzed cement, he found it to be largely the oxides of lime, alumina, silica, magnesia, and iron. Supplied in the proper proportions and heated to about 1425 degrees, these materials are the source of our cement. This wonderful building material of the chemist adds untold durability, safety, comfort, and healthfulness to our homes.

As materials for the building, brick and tile are almost indispensable, being used for walls, chimneys, flues, fireplaces, and roofing. With bricks so common, we are prone to think that the chemist has nothing to do with their production. But as they are manufactured from many types of clay, the chemist must determine the type and composition of all clays. If a clay lacks some essential element, an inferior product results. Even the lumber used in the modern building is chemically treated and cured to give the wood longer life, to prevent swelling, and to reduce the fire hazard.

All of us are acquainted with paints and varnishes and their use, but few are aware that it was only after scientific synthesis and analysis began that the paint industry made much progress. Of course the primary purposes of paint and varnish are protection and beauty, but from the standpoint of sanitation and hygiene, painted walls are recommended. It has been found that vapors from an oil-pigment paint develop formaldehyde, an antiseptic that destroys bacilli. The use of protective coating began before 2500 B. C., when Noah covered the Ark with pitch. The ancient Egyptians, Greeks, Assyrians, and Romans were great believers in the decorative art. Colors were obtained from the earth, such as yellow ochers and red iron oxide. Practically all paints are now made by grinding mined or chemically prepared pigments in oil, subsequently adding a thinner, such as turpen-

tine and a drier of cobalt, lead, or manganese. Varnishes are produced by combining resin, heat-treated drying oils, a thinner of turpentine, and driers that act as catalysts. Quick-drying lacquers have recently been made from low plasticity nitrocellulose. There are, however, over a thousand materials coming from all parts of the world with which the chemist must be familiar in order to have a thorough knowledge upon which to base his processes and formulas.[1]

By chemical experimentation, attractive fireproof roofs of asphalt and asbestos compounds have been developed. Insulating materials have been compounded for the building, which greatly reduce the fuel bill. These materials are often glass wool or silicates of magnesium. The interior finish is often plaster, a chemical compound of hydrated calcium sulfate. Or, if you like, the walls are paneled with fascinating new chemically prepared materials.

Although glass making is an age-old art, it was the chemist who gave us glass that permits the health-giving rays of the sun to enter our homes and allows perfect vision. The chemist has given us special glass adapted for definite purposes. He found that glass not too high in sodium or potassium possessed low conductivity, hence its use in electric light bulbs. By adding boracic acid, he produced a glass of a low expansion coefficient for oven use. Besides these articles, we have dishes, tumblers, shades, pots, jars, bottles, and various containers of glass. Undoubtedly, modern glass is one of the chemist's most important contributions to the home.

The modern heating system that supplies uniform temperature throughout the house is possible because the chemist understands the refining of petroleum, the preparation of fuel gases from destructive distillation of coal, and the combustion of oils and gases. Furthermore, by improving the metallurgy of iron and steel, the chemist provides the furnace in which the heat is generated. By simply pulling a cord, the modern furnace is placed in operation. Through research, the chemist has replaced the heating methods of yesterday with something more healthful, convenient, and efficient.

Today, we think it would be impossible to do without electric lights, and if it were not for chemistry, they would be impractical. An electric light bulb is made of glass with a filament of tungsten and thoria, which makes light from electricity possible. To transfer this energy from which light is produced, the chemist provided pure copper wire, properly insulated. The electric light, by removing limitations on the activities of the home and giving us wonderful convenience and safety, has advanced civilization many years.

Since prehistoric time, man has created fire at will, yet not until the ad-

[1] Howe, H. E., "Chemistry in Industry," Vol. II, The Chemical Foundation, Inc., New York City, p. 232, 1927.

vent of the match in the nineteenth century could he do this with so little inconvenience. Although people use matches every day, they never stop to think that each one is a splint treated with glue, chlorate of potash, sulfur, resin, and sesquisulfide of phosphorus. The development of the "match" for home use is a striking illustration of the application of chemistry to human needs.[2]

With the idea in mind that "a little fire is quickly trodden out," the chemist constructed the automatic sprinkler, and the chemical extinguishers for home protection. But perhaps the most effective way to combat fire is to prevent it by building the home of fireproof materials, such as cement, brick, steel, plaster, and asbestos, developed by the chemist.

In furnishing the home, it is transformed from a bleak, barren place to one of beauty and comfort by the science of chemistry. The gorgeous display of color and beauty in the home is possible because synthetic dyes of beauty and fastness can be prepared from dirty and ill-smelling coal tar. When the total elimination of color is desired, a process of bleaching with hypochlorites and certain peroxides is employed. The beautiful draperies, curtains, and even articles of clothing are often made of artificial silk. Count de Chardonnet first produced this silk from cellulose. Cellulose is the structural material of vegetation, and is very plentiful in cotton, wood, and flax. A host of articles including paper, artificial leather, and celluloid are products of cellulose.

Sanitation and cleanliness are the distinguishing marks of our civilization. The successful home is an example of cleanliness through chemistry. Soap is distinctly a chemical product, being an alkaline metal combined with mixed fatty acids. Although soap was made during Biblical times, improvement in its manufacture was slow until the last century, when Chevreul determined the true chemical character of fats and soaps. Beside soap, there are many important detergents for stain removal. In the bathroom and kitchen, where sanitation and cleanliness prevail, the beautiful tiled walls, floors, and porcelain plumbing fixtures are creations of the chemist.

The modern kitchen illustrates better than any other part of the home the tremendous impress which the work of the chemist has forced upon our domestic life. All of our modern kitchen equipment is the result of chemical research. The utensils for cooking are of infinite variety. Aluminum, possibly the best material for this purpose, was unknown a hundred years ago. The home is indebted to the chemist Hall for the economical production of aluminum by an electrical process. The mystery that shrouded the metallurgy of iron and steel was uncovered years ago; consequently, we now have our wonderful gas and electric ranges and hundreds of other contrivances and appliances. Rustless steel and other alloys have been developed. Our enameled ware has been improved. Silverware has a

[2] H. E. Howe, *op. cit.*, p. 221.

distinct chemical history. Ordinary linoleum is a mixture of oxidized linseed oil, cork dust, fillers, and pigment mounted on a canvas back. Without mentioning other common kitchen articles, it is apparent that the chemist really blessed the home when he introduced chemistry into the kitchen.

Modern refrigeration methods are possibly the chemist's greatest contribution to the welfare and comfort of the family. From the simplest ice box to the new refrigeration machines, underlying principles of chemistry are involved. In producing artificial ice and maintaining low temperature, ammonia is necessary because of its high heat of vaporization. Where small units are necessary, sulfur dioxide is employed. The Frigid aire machines are of this type. Although there are other types of chemical refrigeration that will come into extensive use in the future, the most popular now is the compression machine. Its success lies in the fact that ammonia gas, when compressed and cooled, forms a liquid. The ammonia is then vaporized, absorbing heat and thus creating a low temperature. When the chemist gave us unlimited quantities of ammonia, he provided our homes with foods that were formerly unavailable.

There is nothing in the home of more importance to the welfare of each individual than the foods. However, little is known of the relation of foods to health and disease. We must accept food as the very essence of life, but we do not realize that some one has protected us from danger. This invisible person is the chemist. He has protected us from impure foods by setting legal standards for pure foods. Louis Pasteur protected our milk supply when he introduced pasteurization. We must also remember that our water supply is effectively purified and softened when necessary by the chemist. He analyzed foods and found them to be carbohydrates, fats, proteins, vitamins, and mineral matter. By research, he has helped us to know what to eat and the amount we require. Synthetic foods and combinations not found in nature are provided, as baking powder and soda. Because of his accomplishments, the chemist is recognized as a most important person in food production, control, and utilization.

Although we have access to adequate medical service, the home must be able to render first aid. The medicine chest should contain simple remedies, preventives, and antiseptics that the chemist has provided.

During this quarter of a century, radio has annihilated space and brought untold pleasure into the home. The chemist has supplied the tubes and materials that make radio a reality; and, just as radio is dependent on chemistry, so will the intricate television machines of the future be. Our newspapers, books, and magazines are all possible because the chemist produced the paper, ink, and glue from which they are made. In fact, it is safe to say that the chemist provides the home with all of its recreation and entertainment.

From this meager description, it is apparent that there is nothing in the

home that does not have a romantic chemical history. Chemistry is everywhere evident; and to describe completely the chemistry embodied in the home, would require hundreds of volumes; possibly even then many fascinating principles that affect our daily life would remain hidden, because the chemist is a poor press agent. Chemistry affects all members of the family more than they will admit; even Dad, when he chooses a tie, takes a particular one because the chemist saw fit to dye it a certain color. In the future, chemistry will influence and enrich our home life to an extent now unimaginable because it is a creative science that treats of the transformation of matter, and such transformations may be unlimited in number and variety. We are conservative when we say that chemistry is a science the first chapter of whose book of Genesis is just beginning to be written.

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**Spiral Chart Shows Relation of Elements.** A few years ago matters pertaining to the arrangements of the chemical elements would have been supposed to be purely the affairs of chemists, but recently the American Physical Society, meeting with the Pacific Division of the American Association for the Advancement of Science at Berkeley, California, heard how a spiral curve can be used for convenience in studying them. Modern developments in both physics and chemistry have brought them so close together that the once sharp dividing line between them has almost completely disappeared.

Dr. A. E. Caswell, of the University of Oregon, told the physicists that the elements could be put on the spiral curve, starting with hydrogen at the center and traveling outward to uranium, the highest. Elements of the same family are along the same radial line, while the non-metals are on one side and the metals on the other.—*Science Service*

# THE RELATION OF CHEMISTRY TO THE DEVELOPMENT OF A NATURAL RESOURCE—COAL*

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In the field of the chemistry of coal and its derivatives science has made conspicuous progress, and the fact that much research is being directed to this field is significant. The economic status of the coal industry has been for some time precarious, but if the industry avails itself of the services of chemistry to an even greater extent than heretofore contemplated, the likelihood of its rejuvenation and ultimate supremacy in the fields of industrial power and certainly in the field of chemical derivatives is great.

Coal fields heretofore valueless by reason of location, quality of coal, etc., may be profitably developed if one of the great dreams of industrial engineering comes true; that is, the establishment of great central power and by-product recovery plants at the coal fields, the energy of the coal being there changed into easily transportable form, such as liquid coal, or gas (by the newly developed liquefaction and gasification processes, or electricity), and the innumerable chemical derivatives obtained. Such an industrial step will ultimately be necessary, and the economy under such a system, both of the natural resource and of the energy required for its exploitation, will be tremendous.

HERMAN STEFFAN

Regarding the question of the exhaustion of the coal fields and the cutting off of the source of raw material, no fear need be entertained. We have only scratched the surface of the available coal deposits, and the following figures, taken from "Coal Resources of the World,"[1] indicate the enormous resource from which we have yet to draw.

Available coal classified according to kind in millions of metric tons:

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|---|---|
| Anthracite and some dry coals | 496,846 |
| Bituminous coal | 3,902,944 |
| Sub-bituminous, brown coals, lignites | 2,997,763 |
| Total (in millions of metric tons) | 7,397,553 |

* Prize-winning normal-school and teachers' college essay, 1928–29.

[1] Moore, E. S., "Coal," John Wiley and Sons, New York City, 1922.

These figures are based on geological surveys which were not in all cases complete, and the actual figure would probably be much greater.

Compare 496,846 millions of short tons of coal used throughout the world from 1911 to 1916 inclusive, under non-favorable and generally uneconomic and disrupted conditions. This comparison shows that the available coal supply is amply sufficient to last the world until science develops means of doing without it.

The importance of coal in the political development of any nation is plainly shown by history, "the accessibility of large coal deposits being an essential factor in her industrial development."[1] These facts being borne in mind, the consideration of the greatest contributory factor to the importance of coal, not only as a fuel, but as a raw material from which many useful and invaluable compounds are derived, will be taken up. That prime factor is chemistry, and we propose to present some of the reasons why the coal industry is dependent upon chemistry by pointing out its more obvious contributions and some of its more recent developments.

Firstly, in the utilization of coal as such, as a fuel, chemistry has been instrumental in effecting desirable changes. Research has made possible greatly increased efficiency in the consumption, especially in steam power plants, factories, and on locomotives. Standards have been determined experimentally for various kinds of consumption, so that the maximum of efficiency may be achieved together with a minimum of fuel used. Such a harnessing of heretofore wasted energy will release more coal for use in the many processes which will be discussed later.

By means of a process known as briquetting, waste coal, coal too fine for consumption in the ordinary type of burner, may be compressed and held together by a cohesive binder, and thus utilized in the form of clean, easily handled briquets. In Europe, this means of using up waste coal has been successfully employed for some time. Power stations are also making use of powdered coal and coal dust as a source of energy, showing that all the coal may be consumed.

Secondly, the destructive distillation of coal. This process yields coke, fuel gases, ammoniacal liquor, and coal tar. The uses of coke as a fuel and in the manufacture of steel are well known, but chemistry demonstrated the increase of efficiency that might be obtained by examining the coals and determining their coking possibilities, and was in part responsible for the supplanting of the old beehive coke ovens by by-product ovens wherein the recovery of the valuable gases, liquors, and the tar is possible.

Fertilizers rich in available nitrogen are made from the ammonia compounds, and agriculture has profited by such products.

Coal gases for both light and fuel have long been in use in the cities, and are still a factor of importance, although electricity is supplanting them to a certain extent, especially for lighting.

From coal tar over 200,000 valuable chemical compounds have been made, and we shall discuss some of the more important classes of derivatives here.

## Dyes

Perhaps one of the most interesting accounts to be found in the annals of industry is that of the development of coal-tar dyes. Coal-tar products are made which supplant and excel all of the formerly used vegetable dyes, such as indigo and madder, and many more colors can be synthesized than are to be found in nature. About 1000 coal-tar dyes are in constant use, and at least 10,000 have been made in the laboratory. When we consider that 500,000 pounds of dyes are used in this country in food and drink alone, the great extent of their application is apparent.

The first synthesis of a coal-tar dye was brought about accidentally by Perkin in 1856. Now nearly all shades, colors, and kinds of dyes to suit every purpose or condition are available, and these synthetic processes save the world great sums of money each year, by producing dyes that are much cheaper than the natural dye would ever be. According to E. E. Slosson, the synthetic manufacture of alizarin is now saving the world about $20,000,000 per year.[2]

Chemistry strives to meet the various perplexing problems that come up in the dye industry; for instance, dyes must be made to withstand perspiration, sunlight, and they must be enduring. For different kinds of cloth, different dyes are needed. In general, the fast colors are less brilliant than those that are liable to fade.

Aniline dyes are used in chemo-therapy to stain disease germs, thus making them visible and capable of study under the microscope. Different dyes attach themselves to different bacteria, thus making the differentiation of disease bacteria possible. This use of dyes was made known by Paul Ehrlich, and the great discoveries in the field of medicine that have been contributory to the health of the world, such as those of Robert Koch, have been facilitated by these staining processes.

In the synthesis of dyes, heretofore rarely used compounds, such as benzaldehyde and aniline, became of great importance, and the problem of procuring these cheaply was solved by the experimental chemist. Mordants were made also, which would permit the use of the same dye on different fabrics by forming a base to which the dye can attach itself.

Dyes are used, in addition to their ordinary purpose, as chemical indicators in the laboratory.

## Explosives

Explosives have an important place in coal-tar derivatives. Safe explosives which can be set off with terrific force, but only with the right sort

[2] "Coal Tar as a World Power," *World's Work*, Jan., 1923.

of a detonator, are in constant and increasing use in industry, and of these high explosives the most are coal-tar derivatives. Picric acid and T. N. T., both derived from benzene, a coal-tar hydrocarbon, demonstrated their efficiency as high explosives during the World War, and now similar powders find extensive employment in great construction projects, agriculture, and the like.

## Drugs

From coal-tar products, numerous valuable medicinals have been made. In 1874 Koble made salicylic acid from phenol, and gave the impetus to the derivation of drugs from coal tar. Early chemistry was a branch of early medicine, and the old experimenters at the time of Paracelsus got no little satisfaction in discovering new concoctions that were helpful in any way to the then embryo science of medicine. Now, as then, chemistry is the power behind the throne, but in a manner that far eclipses its early contributions. Modern medicine is entirely dependent upon chemistry for anesthetics, antiseptics, drugs, and medicinals of all kinds, and these finer compounds are for the most part organic, derived largely from coal tar.

In 1881 the first coal-tar drug was prepared, and since that time numberless pharmaceutical compounds have been made, many from coal-tar constituents.

Some drugs combat the symptoms of a disease but do not possess the curative properties that might be desirable, so technical investigation is necessary to determine what factor may be lacking and what alterations in the structure of the compound will bring about the desired change. The innumerable coal-tar compounds afford a choice of almost any grouping of the organic elements, and to them the chemist turns in synthesizing these necessities to human health.

Familiar drugs from coal-tar are aspirin, adrenalin, and acetanilide, for example. It would be useless to name more, or to discuss their method of preparation. In general, anesthetics are not made from coal tar, but some important local anesthetics have been synthesized from coal-tar constituents.

As we have pointed out previously, certain types of coal-tar dyes are toxic to disease bacteria, being absorbed by the parasitic body without affecting the surrounding tissue. Recently, certain dyes have been used in the treatment of blood poisoning also.

## Perfumes

Odoriferous bodies can be synthesized which are identical with certain constituents of natural essences, such as hyacinth, and perfumes can be made which merely imitate the natural odor. Perfumes today contain, usually as the main constituent, synthesized sweet-smelling bodies which are made generally from coal-tar derivatives.

## Photographic Chemicals

Films can be dyed with coal-tar dyes, thus rendering them more sensitive to certain colors of light; such treatment makes the orthochromatic plate which is especially sensitive to green and yellow light, and the panchromatic plate, which is equally sensitive to all colors. In addition to this use, coal-tar compounds furnish most of the photographic developers. Many different developers are available, and the exacting worker can choose from a large number of possible compounds, the one which will bring out the best in the negative.

This brief outline has shown the more important ways in which the exact sciences, especially chemistry, have contributed to the development of coal in the past. Since the World War, coal has been the subject of intense research, and some of the possibilities and new uses which have been developed are of interest. As was pointed out at the Second International Conference of Bituminous Coal, by Dr. Karl Krauch, director of the I. G. Farbenindustrie Akt.-Ges., "the synthetic production of basic compounds from coal is of utmost importance to Germany's economic future,"[3] and in that country some of the more startling discoveries have been made. The catalytic processes developed by I. G. chemists and the hydrogenation process of Dr. Friederich Bergius are generally combined in the synthesis of liquid hydrocarbons, such as gasoline, kerosine, lubricants, and fuel oils from coal. The commercial success of these processes is shown by the fact that an annual production of synthetic gasoline to the amount of 70,000 tons has been achieved at a plant in Leuna, Germany, and much greater yields are anticipated.

Catalysis is a phenomenon which causes the chemical union of two substances without change in the catalyst itself. The principles of its operation are not well established, yet chemistry has been able to apply these processes successfully to the syntheses of hydrocarbons from coal and hydrogen. The yield of any specific product, such as gasoline, is increased with one catalyst, while another may increase the yield of fuel oils.

Dr. Bergius' hydrogenation process consists essentially in adding hydrogen to the carbon of the coal. Necessarily, then, processes for the cheap production of hydrogen will be developed, the logical source being water, or, perhaps, some of the gaseous products of the distillation of coal, such as methane, $CH_4$, could be decomposed and the hydrogen thus obtained utilized.

Engineers and chemists prophesy the coming of the general use of liquid and gaseous fuels, owing to their greater practicability. Liquid coal is being used as a fuel in Germany, where its possibilities are being successfully demonstrated.

[3] "Food, Oil, Gas from Coal," *Science News Letter*, Nov. 4, 1928.

The development of a satisfactory, smokeless domestic fuel from coke is an advance in public health as well as in fuel economy, since the smoke, which is a suspension of fine, solid particles, has been shown to shut off a by no means negligible percentage of the ultra-violet light[4] which is necessary to growth, and the mechanical irritation of such particles in the eyes especially is by no means desirable.

So we see that, no matter what specific use of coal we investigate, the handiwork of the chemist is apparent. He assists in the efficient and economic consumption of coal as fuel and a source of power. He derives countless products from the destructive distillation of coal. He can even use the dust of coal as a source of energy, and edible fatty foods and soap fats[3] have been synthesized from coal. He has demonstrated the possibility of making a light, strong building block which may be permanently tinted any color from a derivative of coal.[5] His contributions to the fuel economy of the past have been great, and in the future, the working out of the economic status of coal may well be left in the hands of the chemist, who has already done wonders in that direction.

Research dealing with such subjects as the hydrogenation of coal into oils, the synthetic production of methanol and other compounds, the carbonization of coal at both low and high temperatures, the gasification and liquefaction of coal, the utilization of the coal-tar derivatives, the making of coke into a satisfactory and efficient domestic fuel, coal as a source of commercial fertilizer, wider uses for Bakelite and such compounds from phenol, a coal-tar product, and the numerous other fields with which the chemistry of coal concerns itself will ultimately contribute to the economic success of the coal industry, greatly influence industrial activity, and initiate in the world that which may have greater bearing upon the political success of nations, the prosperity of the world, and scientific progress, than any factor of the past—the new, real "Coal Age."

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**Sweeter Milk Sugar Made Commercially.** A form of milk sugar, called beta lactose, sufficiently sweet to be used as a table sugar, is about to be produced commercially through the efforts of Dr. John Harvey Kellogg, director of the Battle Creek Sanitarium.

The usual form of lactose is a chalk-like, slightly sweet powder that is difficult to consume in quantity. Since milk sugar is sometimes used therapeutically as a substitute for ordinary table sugar, chemically known as sucrose, the production of a form of lactose three times as sweet and three times as soluble as commercial lactose is likely to prove of value to medical practice. Patients will be able to substitute the beta lactose for the common sucrose of the table and this milk sugar will be taken as a food rather than an unpalatable medicine. It is about a third as sweet as ordinary sugar and will cost about fifteen to twenty times as much per pound.

Some physicians believe that lactose is preferable to the ordinary sucrose, produced from sugar cane or sugar beets, as a source of sweet carbohydrate in the diet. It is more slowly absorbed in the system than other sugars and it is claimed to promote the growth of more beneficial bacteria in the lower portion of the alimentary canal. Lactose is formed nowhere else in nature than in the milk of mammals, not even in their blood. The fact that the bodily processes take the trouble to make this special sugar for the mother's milk caused scientists to discover that lactose seems to play an important part in keeping babies free from such diseases as typhoid, dysentery, and cholera. Predatory microbes cannot thrive in the infant's food tract because they cannot live in the lactic or buttermilk acid that the fermentation of lactose produces. A special sort of bacteria, *Bacillus bifidus*, populates the lower food canal of nursing babies and these bacteria are the helpful agents that transform the lactose into the protecting lactic acid.

The theory back of the suggested substitution of lactose for sucrose as a special dietary measure is that such a protective bacterial action would be created in the lower food tract of the adult by the liberal use of the milk sugar.

It has been known for seventy-five years that lactose exists in two forms having the same chemical composition, twelve atoms of carbon, twenty-two atoms of hydrogen, and eleven atoms of oxygen to the molecule, but differing in physical properties. A quarter of a century ago, Dr. C. S. Hudson, the American sugar chemist formerly at the U. S. Bureau of Standards and now at the U. S. Hygienic Laboratory, clearly described the making of the sweeter beta form of lactose. From a solution of alpha lactose or milk sugar of commerce, the beta sugar can be crystallized out at a temperature above 200 degrees Fahrenheit.

Nearly two-fifths of the total solid content in cow's milk consists of lactose and it is estimated that over a third as much lactose as cane sugar is consumed annually when the lactose content of milk is considered. Dr. Amé Pictet, the Swiss sugar chemist, recently announced that he had succeeded in synthesizing lactose but the possibility of producing milk sugar in this way, or any other way than from milk, is quite remote.—*Science Service*

# FACTORS DETERMINING ELECTROLYTIC DISSOCIATION

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In this paper we desire to point out some of the influences of solvent and solute structures upon the properties of solutions. We are interested primarily in those properties which determine the electrical conductivity of the solutions. The question of fundamental importance is that which deals with the structures of both parts of such mixtures. Not only do the characteristics of the constituent atoms of the molecule determine its behavior in the presence of other molecules, but molecular properties also depend upon the arrangement of atoms within the molecule and the nature of the linkages by which they are held together. Just as the number and arrangement of the electrons within the atom determine the properties of the atom, so do the properties of molecules depend upon the number, the kind, and the arrangement of their atoms. In fact, we may go farther and say that in many cases the reactions of the valence electrons of the various atoms among themselves largely and directly make the compound possible and determine both its stability and its behavior. The nuclei and kernels of the atoms are of significance only to the extent that they prohibit or permit the valence electrons to take part in such reactions. This control over the valence electrons is exercised in a measure dependent upon the size and charge of the nucleus and the distance that separates it from the valence electrons. This, it seems to the writers, is the contribution of the electron theory of valency to the problem of molecular constitution.

Among the properties of the solvent medium which have been said to have a marked influence upon its ionizing power, that is upon its ability to cause electrolytic dissociation of solute molecules, is the dielectric constant. We have followed the lead of Thomson[1] and Nernst[2] who first suggested that the ionizing power of a solvent is determined by its dielectric constant. This, of course, is not strictly true. Kraus[3] has pointed out that for a given electrolyte there is a certain concentration in every solvent, regardless of its dielectric constant, at which the ionization is the same. It is the form of the conductance curve rather than the absolute conductivity that seems to be related to the dielectric constant. This relationship cannot be disregarded, but its supreme importance must be denied as long as the experimental data do not confirm it, other than to show that the dielectric constant of the solvent gives the general order of magnitude of the constants which determine the form of the conductance

[1] J. J. Thomson, *Phil. Mag.*, **36,** 320 (1893).

[2] W. Nernst, *Z. physik. Chem.*, **13,** 531 (1894).

[3] C. A. Kraus, "The Properties of Electrically Conducting Systems," Chemical Catalog Co., N. Y., p. 89, **1922.**

function. For instance, sodium iodide has a mass action constant ($K \times 10^4$) of 34.0 in acetophenone (dielectric constant 16.4), 23.0 in methyl ethyl ketone (dielectric constant 18.4), 12.0 in isobutyl alcohol (dielectric constant 18.9), 28.0 in ammonia (dielectric constant 22), and only 5.85 in isoamyl alcohol (dielectric constant 15.9). Variations are regular in solutions of the same constitutional type. This strongly suggests that the dielectric constant of a solvent and its ionizing power are not primarily related and that the one does not depend upon the other. They are properties which are dependent upon the same factor, namely, the structure of the solvent molecule. The same property of the solvent which makes it a medium of high dielectric constant also permits it to react with molecules to bring about their electrolytic dissociation.

When two charged points are separated by a medium, the force exerted between them depends on the value of the charges, $e^1$ and $e^2$, the distance between them $d$, and the nature of the medium:

$$F = e^1e^2/Dd^2$$

where $D$ is known as the dielectric constant of the medium. The greater the value of $D$, the smaller the force exerted between the point charges and so, in the case of solutions, the greater the degree of ionization of the molecule which is composed of the two ions here represented as the two point charges. In the case of a pure liquid, such as water, the magnitude of the dielectric constant is usually considered as dependent upon the electrical moment of the water molecule as dipoles. To possess such moment the molecule must be polar in nature; it must consist of two parts, one of which contains an excess of positive and the other an excess of negative electricity. When such a liquid is placed in an electric field, the electric doublets, represented by polar molecules, are oriented in such a manner as to produce alternate layers of positive and negative electricity. This orientation is due to the tendency to reduce the intensity of the field. Sidgwick defines the dielectric constant "as a measure of the work that must be done by the external field in orienting the molecules against their thermal agitation." We cannot say, however, that the magnitude of the dielectric constant is absolutely dependent upon the presence of polarized molecules in the liquid, since $D$ is still a factor in the above equation when the medium is one whose molecules are non-polar and the electric moment is zero. There may here be found a part played by magnetic moments in developing a type of polar molecule not dependent upon static charges alone. Such magnetic fields arise from electronic motion and have long been considered to play a part in the forces exerted by molecules upon particles such as ions or other molecules with which they come in contact.

It is in this field that much investigation of the properties and the behavior of solutions must be made. The writers are engaged in such studies,

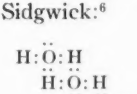
and it is with the hope of encouraging work and thought along these lines that the present paper is written. Brönsted[4] has already pointed out the almost total lack of data dealing with a somewhat limited portion of this field, namely the influence of the medium upon what he calls the acidity and basicity constants of substances dissolved in the medium.

To possess electrical moment a molecule must be somewhat polar in character. There must be dissymmetry in the distribution of electric charge. The bonding pairs of electrons are almost completely transferred from the field of one atom to that of the other, and electrostatic forces that arise in this manner serve to hold together the positive and negative portions of the molecule. Such compounds dissociate almost completely and with ease into ions. We may speak of the bonds between atoms that are linked in this manner as "electrovalences." On the other hand, if the valence electrons exist in the molecule in such manner and if they describe such orbits that we may say that they belong equally to both atoms, the atoms will have the same charge, and the total electric charge of the molecule is symmetrically distributed. These do not dissociate into ions and are often called non-polar molecules. True non-polar linkage exists only in such molecules as $N_2$, $O_2$, etc. In any heterogeneous molecule the shared electron pair necessarily must be displaced toward one or the other atom. Atoms of two different elements can scarcely be expected to possess exactly equal attraction for electron pairs. There is always some dissymmetry in the distribution of the electric charge when two different kinds of atoms are linked together, and this can be observed by the examination of the infra-red absorption spectra of the compounds. In many compounds, however, the dissymmetry that is produced is very slight and there is little molecular moment. Carbon tetrachloride contains four pairs of shared electrons that are undoubtedly displaced toward the chlorine atoms of the molecule, but the electric charge of the molecule is so nearly symmetrically divided that the molecular moment is very slight. The dielectric constant is low, and the molecule does not dissociate into ions.

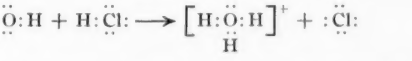
The bonds between atoms in non-polar molecules are often called "covalences." Molecules, in which the bonds between atoms are covalent, possess dielectric constants of small magnitude unless the link is one of the coördinated covalence type. Molecules that contain lone electron pairs (unsaturated atoms) may form such linkages with atoms or groups in which incomplete "octets" of shared electrons exist. They may also combine with themselves, provided that the molecule contains one atom which may act as donor of the electron pair and another that may act as acceptor of it. Such action leads to molecular association. Thus,

[4] J. N. Brönsted, *Chem. Reviews*, **5**, 231 (1928).

water may become associated in the following manner as suggested by Latimer and Rodebush[5] and Sidgwick:[6]



It may also react with solute molecules or ions in much the same manner. Thus, in the ionization of hydrochloric acid in water we are now accustomed to think of the process as occurring in the following manner:



The free hydrogen ion is not thought to exist in solution.[7,4]

The hydrogen ion acts as the acceptor of the free electron pair of the oxygen atom, and through this coördinated bond forms the "oxonium ion."

Many writers[8] have preferred to refer to the hydrogen-accepting property of the solvent as its basicity. In speaking of the coördinated covalency of donor atoms we are only trying to assign some reason for such basic action.

The presence of dipoles leads to electric fields about the molecules and has been considered the cause of many of the properties of polar substances, such as high latent heats of vaporization, high internal pressures, high dielectric constants, molecular association, and compound formation with other components of the solution. There is a tendency, however, among some exponents of the electron theory of valency to assign the cause of molecular association to the presence of atoms within the associating molecules that may act as donors and acceptors, respectively, in forming coördinated covalent linkages. Water and similar compounds containing a hydroxyl group have high dielectric constants (according to Sidgwick) because of their tendency toward molecular association, as indicated above for water. Dipoles within the associated molecules result when the oxygen atom of one molecule acts as a donor to the hydrogen atom of another molecule. This polarity is due, no doubt, to the fact that the electrostatic balance between the positive atomic nucleus of oxygen and its outer electrons is disturbed when a pair of electrons originally held by the oxygen atom alone is shared with the hydrogen nucleus.

Latimer and Rodebush have previously seriously questioned the dependence of high specific inductive capacity and association upon the ac-

[5] Latimer and Rodebush, *J. Am. Chem. Soc.*, **42**, 1431 (1920).

[6] N. V. Sidgwick, "The Electron Theory of Valency," Oxford Press, London, p. 123, **1927.**

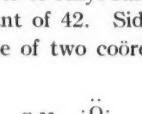
[7] Latimer and Rodebush, *J. Am. Chem. Soc.*, **42**, 1425 (1920).

[8] J. N. Brönsted, *loc. cit.* See also for other references to work of Kendall, Hantzsch, Lapworth, Harned, and others.

tion of polar molecules as dipoles. They point out that hydrogen chloride should contain dipoles of greater moment than water or hydrogen fluoride, yet it has a much lower dielectric constant both in the vapor and liquid and does not appear to associate. Sachanoff[9] and Plotnikoff[10] pointed out some time ago that the chemical nature of the solvent is of most importance in promoting ionization when the dielectric constant is small. It is only logical that we should try to explain all three of these properties, namely, dielectric constant, ionizing power, and molecular association, in terms of electronic configuration, which serves as a new tool for the study of the behavior of molecules.

If we accept the idea of the coördinated covalency, it is apparent that molecular association, high dielectric constant, and ionizing power are all dependent upon the presence of donor and acceptor atoms within the solvent molecules. It is quite possible, if these properties are not dependent upon one another, that a given solvent may possess a low dielectric constant and may exhibit little or no tendency toward molecular association, but still possess fairly strong ionizing power. The ethers (dielectric constant about 4) may be such substances. In the molecule of diethyl ether the hydrogen atoms of the ethyl groups cannot act as acceptors; hydrogen linked to carbon almost never forms coördinate linkages. The oxygen atom of the ether molecule, however, may easily form coördinate linkages with atoms of solute molecules in the same manner that the oxygen atoms of water, alcohols, phenols, and carboxylic acids may combine through their lone electron pairs with hydrogen ions and other acceptors. These last-mentioned substances contain hydroxyl groups, and the hydrogen of this group may act as an acceptor. They tend to associate, therefore, and have fairly high dielectric constants. It would be interesting to study the electrical conductivities of different types of solutes in ethers, with special regard to the value of the dielectric constant and association tendencies of the ethers.

Diethyl sulfite, $(C_2H_5O)_2SO$, with one coördinate bond has a dielectric constant of 16. The ethyl ester of ethyl sulfonic acid, isomeric with ethyl sulfite, has a dielectric constant of 42. Sidgwick thinks that this is undoubtedly due to the presence of two coördinate bonds between oxygen and sulfur:



The writers predict, however, that the ionization of the same solute in these two or similar solvents would not be found to greatly differ, since

[9] Sachanoff, *J. Russ. Chem. Soc.*, **42**, 1363 (1910).
[10] Plotnikoff, *Z. physik. Chem.*, **45**, 193 (1913).

the oxygen atoms of each molecule are able to act as donors of electron pairs. In the same manner one might investigate the dimethyl and diethyl sulfides and their oxygen derivatives, the sulfones. In the sulfones oxygen forms coördinate links with sulfur. Because of such linkages the dielectric constant should be increased, but the ionizing power or basicity should not be affected greatly, unless the formation of a coördinate link by oxygen with sulfur prevents its acting as donor to a positive ion, for example, the hydrogen ion. Since it acts as the acceptor of the electron pair of the sulfur atom, it should become slightly negative in electrical character and its hydrogen-accepting properties should be greater than those of the covalently linked sulfur atom in the sulfides. There should be little tendency toward molecular association in either case because of the absence of acceptor atoms. Acetone should be associated to an extent that is dependent upon the presence of the enol modification.

The presence of associated solvent molecules, while leading to conditions that may result in increased dielectric constants, may be expected to result in decreased ionizing power. If lone electron pairs of donor atoms are used in promoting association, the same atoms cannot combine with the acceptors of solute molecules as completely as they do in the absence of association. Some study should be made of the effect of those factors that influence molecular association upon dielectric constants, electrical conductivity, and ionizing properties of the medium.

Structure has already been mentioned as one of these factors. Temperature is another. Still another is the electronegativity[11] of the group which, for example, replaces H in H—OH. As the electronegativity of this group increases, the dielectric constant, the tendency toward association, and the ionizing power should decrease. Lone electron pairs on oxygen atoms will be held more firmly according to the theories of electronic structures of Lewis and others; the activity of the atoms as a donor will be decreased. This is, of course, in partial agreement at least with studies on the properties of water, alcohols, organic acids, and their mixtures.

Sidgwick has suggested that the low degree of ionization of weak electrolytes, such as acetic acid, in water is due to the presence of an equilibrium between two types of acid molecule. In one the hydrogen atom is linked electrovalently, and in the other the bond is covalent. About 99.5 per cent of the molecules in water solution are of the latter type. To the writers it seems that the more logical assumption to make in the case of the organic acids is that the donor oxygen atoms of water and of the —COOH group are competing for the hydrogen atom of the acid. In the carboxyl group hydrogen is held not only by the oxygen of the hydroxyl

[11] As the term is used here, that atom is most electronegative which most strongly attracts the bonding electron. In a radical or group the attraction of the central atom (C in $CH_3$, for example) is modified by the character of the atoms attached to it.

group by a normal covalency, but, when freed from this linkage, it may also become attached coördinately to either oxygen of the carboxyl group; that is, because of its oxygen atoms with electron pairs that may form coördinated linkages, the —COO— group may be said to possess a certain degree of basicity toward $H^+$. The oxygen atoms of the carboxyl group may act in the rôle of donor atoms almost as strongly as the oxygen atoms of water molecules. The donor activity is modified somewhat by the presence of $CH_3$— groups within the molecules. It is granted, of course, that the formation of any kind of coördination linkage is limited by the normal covalent bond between oxygen and hydrogen in the —COOH group. Thus the true equilibrium exists between hydrogen attached coördinately to the oxygens of the —COOH group and to the oxygen atoms of water molecules. Factors that modify the donor activity of the water oxygens should shift the equilibrium ratio. Thus, the substitution of $CH_3$— or $C_2H_5$— for H in H—OH may cause more hydrogen to be attached to the $CH_3$—COO— group, since it weakens the competition of the oxygen in —OH. Factors that cause H—OH to associate by forming coördinate links between the oxygen atom in one molecule and the hydrogen atom in another lead to the same result. On the other hand, substitution of more electronegative groups for $CH_3$— in $CH_3$—COO— may weaken the donor activity of the oxygen atoms and permit the hydrogen of the acid to react more readily and completely with the oxygen of H—OH to form oxonium ion, $H_3O^+$. Thus, monochloroacetic acid is more strongly ionized than acetic acid in water, and more strongly ionized in both water and methyl alcohol than in ethyl alcohol.

Neither must we lose sight of the fact that acetic acid molecules are themselves associated through coördinate links formed between the hydrogen and oxygen atoms of the carboxyl groups. Acetic acid is largely dimeric. This further complicates the problem by adding one other factor that limits the acceptor activity of the hydrogen atom toward the oxygen atom of water, alcohol, or other solvent molecules. With so many opportunities of coördinate combination with the oxygen atoms of its own group there is little cause for wonder that its coördinate combination to form $H_3O^+$ is very much limited except as factors, such as substitution, weaken the donor activity of the carboxyl oxygen atoms. Viewed in this light, there is no reason for wonder that HCl should appear strongly ionized as compared with acetic.

In this laboratory we[12] have been trying to determine the properties of organic acids as regards their electrical constitution, which cause them to ionize differently in different solvents, thereby forming solutions of varying conductivity. Of course we realize the great part played by factors other than ionization in conductivity measurements. But all such fac-

[12] Hunt with Briscoe, *J. Phys. Chem.*, **33**, 190 (1929).

tors may, perhaps, be considered as affecting the conductivity of the solution through their immediate effect upon the ionization of the solute or the velocity of the ions as they move through the solution. We have given these factors their proper consideration in drawing our conclusions.

The Lewis[13] hypothesis assumes that the degree of ionization of a carboxylic acid is dependent upon the strength of the bond between the oxygen and the hydrogen atoms of the carboxyl group. This hypothesis leads us to believe that the more electronegative the substituent the more highly ionized the acid. Other factors being equal, the acid containing the more negative substituent group should have the greater conductance, provided that conductance depends upon ionization alone. For example, chloroacetic acid should be stronger than iodoacetic acid, and its solutions should, therefore, have greater conductance. We should expect the two acids to have structures somewhat as follows, since we know chlorine to be more negative than iodine:

This shift of the bond between the oxygen and the hydrogen is due to the force exerted by the negative chlorine or iodine atom, the former causing the greater shift. The nearer the doublet is drawn to the oxygen atom the more easily will dissociation take place.

On these assumptions we should expect chloroacetic acid to have a greater conductance than bromoacetic acid, and it, in turn, to have a greater conductance than iodoacetic acid. This is true in aqueous solution, but in alcoholic solutions we find that the conductances are in the order of bromoacetic, chloroacetic, and iodoacetic.

An alcoholic solution of alpha bromopropionic acid is a better conductor than one of beta bromopropionic acid. This is also true in aqueous solution. This is in agreement with the suggestion of MacInnes[14] that the energy of ionization is connected with the distance between the carboxyl group and, for instance, a combined chlorine atom by the same function as the energy of a system of two electrical charges is affected by the distance between them.

[13] G. N. Lewis, "Valence and the Structure of Atoms and Molecules," Chem. Cat. Co., N. Y., p. 138, **1923.**

[14] D. A. MacInnes, *J. Am. Chem. Soc.*, **50,** 2587 (1928).

An increase in the number of chlorine atoms in the molecule of acetic acid causes an increase in the molecular conductivity. The doublet is displaced more and more toward the oxygen as the number of chlorine atoms is increased. With an increase in $CH_2$ groups one should expect a simultaneous decrease in conductivity of the aliphatic acids. This is true in alcoholic solutions until we reach caproic acid, which has a conductance even greater than propionic. Isocaproic acid has a conductance greater than either propionic or caproic in concentrated solutions but falls below caproic in $N/512$ solution. Even this regularity is not found in aqueous solution.

The —CN and —OH radicals cause great increases in conductance when introduced into the acetic acid molecule. In the ketone acid, $CH_3$—CO—COOH, the presence of the CO group in place of the $CH_2$ group leads to a conductance that is many times greater than that of acetic acid. The substitution of $—NH_2$ for a hydrogen atom in acetic acid, however, lowers the conductance almost 94 per cent. This action of amino acetic acid can probably be explained on the assumption that some of the hydrogen ions which are formed by the ionization of the carboxyl radical unite with the basic $—NH_2$ radical. Such a combination is easily possible, since the nitrogen atom possesses a free pair of electrons that may permit it to act as the donor toward hydrogen, thus forming a compound by coördinated valency bonds. If such is the case, the acid will not liberate hydrogen ion until equilibrium has been established in this system. This is an example of what has been called inner salt formation. This subject has been exhaustively treated by Bjerrum.[15] The failure of the nitrogen atom in cyanacetic acid and the failure of the oxygen atoms in the various hydroxy acids and in pyruvic acid to behave in a manner similar to that of the nitrogen atom in amino acetic acid is not sufficiently explained, however, since in all of these cases there are free pairs of electrons that should permit the atom to act as the donor in forming inner salts with hydrogen ion.

The substitution of an electronegative atom or group for hydrogen in the methyl group of acetic acid causes a change in the positions of the electron pairs about the first carbon atom, according to the Lewis hypothesis. This effect is transmitted to the second carbon and also to the oxygen atoms of the carboxyl group. Due to the attraction of the negative substituent for the electron pair that binds it to carbon, the remaining pairs are drawn in more closely to the carbon and oxygen atoms. The hydrogen in the carboxyl group is thus further separated from oxygen, and the linkage is more easily broken when opportunity to form complexes with atoms of solvent molecules is offered. We might view this matter, however, in a different manner. When a substitution results in the attraction of an electron pair away from the central atom, the other electron pairs

[15] Bjerrum, *Z. physik. Chem.*, **104,** 147 (1924).

about the atom may also move away to produce a symmetrical arrangement. Such an action would cause the pairs about the next atom in the chain to be pulled in toward the kernel of that atom; valence electron pairs would be pulled away from the third atom, and so on through the molecule. This would lead to an alternation of partial polarities throughout a chain. Although this view has been suggested at various times, the writers do not regard it as the most satisfactory explanation of the electrolytic solution behavior of substituted molecules. It seems unlikely that the presence of a negative substituent should cause an atom to attract all of its electron pairs less firmly, but in the light of the present state of our knowledge, we cannot deny the possibility of such effects. It would be of great interest to study the effect upon the oxygen-hydrogen bond in the carboxyl group of an alpha chlorine substitution in the same molecule of an organic acid into which beta and gamma chlorines have already been substituted. The effect of such substitution upon the properties of the radicals themselves should also be taken into consideration. If the theory of alternating polarities, produced as described above, holds true, then the beta substitution should be opposed by the alpha, whereas the alpha and gamma substitutions should augment each other.

It is quite evident that the strength of the normal bond between hydrogen and oxygen in the carboxyl group of the acid cannot alone determine the ionization of the acid. Not only does the character of the substituent group affect this bond, but it may also increase the tendency toward molecular association and the formation of coördinate links with hydrogen ion when the normal bond in the —OH group is once severed. Structures that favor coördinate links and molecular association through atoms that act as acceptors decrease the tendency of hydrogen to leave its original molecular complex to form a new one with the donor atom of the solvent molecule. Future data in the studies of electrolytic solutions must be interpreted in the light of our present knowledge of electrovalence, covalence, and coördinated covalency.

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**Methyl Cellosolve.** Methyl cellosolve (ethylene glycol mono methyl ether) is a new solvent of unusual promise. It is readily volatile, colorless, practically odorless, and completely soluble in water. It dissolves cellulose nitrate and even cellulose acetate (for which there are as yet very few satisfactory high-boiling solvents). By virtue of its unusual solvent powers it is coming into use in the manufacture of rayons, lacquers, airplane dopes, phonograph records, and other cellulose acetate products. It possesses the advantage of a rapid rate of evaporation and a high degree of miscibility with benzol and other hydrocarbons. Its freedom from odor is important in the preparation of lacquers.—*Ind. Bull.* of Arthur D. Little, Inc., No. 27 (March, 1929).

# THE HISTORY OF ELECTRICITY BEFORE THE DISCOVERY OF THE VOLTAIC PILE

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Scientists for many years have believed that Thales, one of the seven Sages of Greece during the period about 600 B. C., possessed the knowledge that rubbed amber acquired the property of attracting light bodies of various sorts, as paper and feathers. Thales of Miletus, the father of the Ionic School of Philosophy, living in the age when the marvelous was always attributed to the Deity, was wont to consider amber as possessed of a soul.

Thus electricity, just as the other sciences, had its beginning more or less shrouded in mysticism and involved in a relation with the supernatural. The unknown was the handmaiden of an all-powerful Deity. This attitude militated against a true scientific search for facts and caused much confusion before it was finally dissipated.

The first written record concerning electricity, which is still extant today, is that of Theophrastus who was writing 300 years before Christ. Not only amber but also lyncurium had the power, when rubbed, of attracting straw, small pieces of stick, or even small bits of copper and iron. The lyncurium of Theophrastus is the tourmalin of today. Pliny in his writings mentions several times the attractiveness which amber possessed, as did also the students Gassendus, Keneln, Digby, and Brown.

For almost 2000 years this knowledge was the extent of all the information concerning electricity. It is strange in a way, and yet is not so unexpected, that all through the glory of the Roman Empire no single philosopher deemed it worthwhile to contemplate on these findings of the Greeks. Possibly they did not have access to the records of the Greeks, or possibly they were interested only in things other than science. At any rate the Roman domination over the world added nothing to the history of electricity.

Then Gilbert, an English physician in London, published his remarkable treatise in Latin entilted "*De Magnete*," in 1600. To us today the work of Gilbert seems almost inconsequential but the value of the history of scientific endeavor lies in the ability of the student to get back into the age of discovery. Amber was the one material known to possess such wonderful, mystical, supernatural powers as to attract other bits of matter. This was the extent of the information when Gilbert wrote in 1600 A. D.

Gilbert found this attractive property of rubbed yellow amber to be also present in the diamond, the sapphire, the amethyst, bristol-stone, and beryl. Glass, when clear and transparent, sulfur, mastic sealing wax, talc, and many other substances possessed the same property of attracting not only straw but also the metals, wood, stones, earth, water, and oil—in short

all solids of any sort. On the other hand, he considered that air, flame, ignited bodies (*i. e.*, rare bodies as they were then called), were not subject to this influence. Dry air was always required to get the best results. Neglect to study this attractive property in dry atmosphere usually vitiated the results.

It was during his work on this subject that Gilbert suggested the name electricity for this phenomenon of attractiveness. He derived this name from the Greek word for amber.

He studied the methods of electrifying amber and the various influences which could vary the virtue of this force. Electric and magnetic attractions were supposed to be different: magnetic attraction consisted of both attraction and repulsion but electric attraction consisted only of an attractivity, never a repulsion.

"Such were the discoveries of our countryman Gilbert, who may justly be called the father of modern electricity, though it be true that he left his child in its very infancy."[1]

Robert Boyle the sagacious investigator of 1570 unearthed several new substances which assumed this power to attract straw, etc., when rubbed. Excited electrics, as he called them, had the power to attract other materials promiscuously whether they had been previously electrified or not, *i. e.*, excited amber could attract the powder of amber and even small pieces of amber. But the power of amber was different from the power of the lodestone which attracted only certain kinds of matter. Boyle's theory of electrical attraction was that the "electric" emitted a glutinous effluvium which laid hold of small bodies in its way, and carried them back with it. This effluvium theory soon had a very strong hold on the philosophers of the period and held on during many of the following years.

Otto Guericke, a contemporary of Boyle, correlated electricity and light[2] but it was left for Wall to develop the relation between light and rubbed amber, etc.,[3] while Newton studied the sparks from rubbed glass.

The conduction of this electricity seems to have been discovered by Hauksbee in 1709[4] though it was not until 1829 when Grey, a pensioner at the Charter House in London, observed the passage of this electric effluvium from one substance through another and recorded the observation.[5] In this record we read that silk was not, though hemp was, a conductor for this peculiar "effluvium." Grey often referred to hair, rosin, glass, and other electric substances as possessing the same property because, while never definitely classifying them as such, he used them many times as insulators.

[1] Priestley's, "History of Electricity," 3rd edition, London, vol. 1, p. 5, **1775.**
[2] "*Experimenta Magdeburgica*," *lib.* **4,** chap. 5 (1672).
[3] *Phil. Trans.*, abridged, **4,** 275 (1700–1720).
[4] "Physico-Mechanical Experiments," p. 75 *et seq.*, London, **1709.**
[5] *Phil. Trans.*, abridged, **8,** 9 (1732–1744).

Liquids were considered for a long time to be insensitive to this electric effluvium for the reason that it was difficult to develop a technic by which they could be studied. This technic was found by Grey[6] when he showed that soap bubbles were attracted by a rubbed amber tube. Then later he electrified a wooden dish full of water, placed on a cake of rosin, or a pane of glass, and observed that if a small piece of sheet glass was held over the water in a horizontal position at the distance of an inch or something more, soap bubbles would be attracted to the surface of the water and then repelled. Water itself was attracted in fine invisible droplets out of a basin toward a piece of electrified amber. Mercury responded similarly though with less intensity.[7]

The growing pains of electricity as a science were serious. In the early days there were only few discoveries with long empty spaces between noteworthy events. To be sure many new substances were studied but new and startling phenomena were seldom reported.

M. du Fay classified more completely the materials which could and could not be electrified, and added the names of many more which he discovered. He was however unable to fire inflammable substances by means of sparks. This led him to suspect no relation between these sparks and fire.[8] Enlarging somewhat on a statement of Guericke he wrote:[9]

> I discovered a very simple principle, which accounts for a great part of the irregularities, and, if I may use the term, of the caprices that seem to accompany most of the experiments in electricity. This principle is, that the electrified bodies attract all those which are not so, and repel them as soon as they become electric, by the vicinity or contact of the electric body....Chance has thrown in my way another principle more universal and remarkable than the preceding one; and which casts new light upon the subject of electricity. The principle is, that there are two kinds of electricity, very different from one another; one of which I call vitreous, the other resinous electricity. The first is that of glass, rock-crystal, precious stones, hair of animals, wool, and many other bodies. The second is that of amber, copal, gumlac, silk, thread, paper, and a vast number of other substances. The characteristics of these two electricities are that they repel themselves and attract each other. Thus a body of the vitreous electricity repels all other bodies possessed of the vitreous, and on the contrary attracts all those of the resinous electricity. The resinous also repels the resinous and attracts the vitreous. From this principle one may easily deduce the explanation of a great number of other phenomena; and it is probable that this truth will lead us to the discovery of many other things.

This discovery according to the account of its author was purely accidental.

M. du Fay at once set out to determine what substances produced each kind of electricity and classified them. He made errors in his deductions concerning these two kinds of electricity but, regardless of these, his ideas

[6] *Phil. Trans.*, abridged, **7,** 19 (1719–1733).
[7] *Ibid.*, abridged, **7,** 23 (1719–1733).
[8] Dantzick, "Memoirs," **1,** 215 and 230 (1743).
[9] *Phil. Trans.*, abridged, **8,** 396 (1732–1744).

were sound and he laid the foundations for a more searching study of the phenomena of electricity.

Passing over the intervening work of Grey, Desaugliers, Hales, Boze, and several German philosophers, the next observation of interest is the success of Ludolf of Berlin in 1744 when he accomplished the ignition of the ethereal spirit of Frobenius by means of a spark from a glass tube. French brandy, corn spirits, and other still weaker spirits by previous heating were kindled even by the sparks projected from his fingers. At almost the ignition temperature he was able to ignite oil, pitch, and sealing wax by means of these sparks.[10]

The first chemical effects of the spark were recorded by Kruger.[11] He exposed the red leaves of wild poppies to the electric spark and found that they were presently changed to white. He could not, however, change yellow colors nor blues except by sparks continued over a day or two.

Ignition by sparks was more thoroughly studied by Miles[12] and Watson.[13]

Following this there was a series of blank years, but in 1745 the "Leyden Phial" was discovered and immediately the knowledge was turned into a means of experiment that led to most singular and astonishing results. The first electrical shock, though very feeble and from very imperfect instruments dumbfounded the discoverers and seems to have almost robbed them of their reason. In the work of Muschenbroeck of Leyden with a phial half filled with water "the effect was so violent that he lost his breath and his sensation, and was two days before he recovered from the effects of the blow and the terror." Popular interest in this instrument in that same year was thoroughly aroused so that its astonishing effects were publicly exhibited throughout the rural sections of England and Europe.

The theories which developed out of the Leyden Phial were studied by all the savants of the day. Complicated ideas were very numerous and the reasons for the various sorts of phenomena were often at variance with each other.[14]

The only criterion by which the investigators could study electricity and its properties, or even its presence, was by the intensity of the sparks that were produced or the shock which could be supported. Shocks were passed through many materials which correspondingly showed that these materials were conductors of this electrical effluvium. All kinds of things were shown to be conductors: plowed meadow-land, water, hedge-rows,

[10] *Phil. Trans.*, abridged, **10,** 271 (1744–1748).

[11] Dantzick, "Memoirs," **3,** 393 (1745).

[12] *Phil. Trans.*, abridged, **10,** 272 (1745–1748).

[13] *Ibid.*, abridged, **10,** 272, 286, 290, 288 (1744–1748).

[14] For a good description of these times see Priestley's "History of Electricity," London, vol. **1,** pp. 102 to 127 (1775). The most intense students were Cuneus, Gralath, Allamand, Kleist, Abbé Nollet, Muschenbroeck, Benjamin Franklin, Watson, Wilson, and several others of less importance.

wet wood, and all metals. This was indeed the era of the development of the ideas concerning electric circuits. The electric shock was transmitted through a wire 12,276 feet long instantaneously.[15]

Various effects of the current passing through wires, etc., were recorded and theories were developed—some indeed were fantastic and to the students of the present day would seem ludicrous—which were then thought to be reasonable. The "weight" of electricity was determined and studied by several men. Medical electricity developed by leaps and bounds during the two years 1747–1748. The virtues of the shock, etc., were marvelous and too deep to be understood. Miraculous cures were accomplished and fame spread like wild-fire through the country districts. "Medicated Tubes" were the boon of the age.

One of the most modest and frank philosophers of the middle of the eighteenth century was Benjamin Franklin who independently in America made startling and unique discoveries. These facts he reported with a simplicity and a perspicuity which could well be made the ideals of all scientists today. Besides studying intensively the mechanics of the Leyden Phial, Franklin interested himself in many natural phenomena in which electricity might or might not be directly concerned; especially was he interested in the electrical nature of lightning. The following quotation from Priestley's History[16] gives an excellent account of the reception of Franklin's theory of electricity:

> The English philosophers, and perhaps the greater part of foreigners too, have now generally adopted the theory of *positive* and *negative* electricity. As this theory has been extended to almost all phenomena, and is the most probable of any that have been hitherto proposed to the world, I shall give a pretty full account of it, and show how it agrees with all the propositions of the last part, to which it has hitherto been applied.
>
> This theory generally goes by the name of Dr. Franklin, and there is no doubt of his right to it; but justice requires that I distinctly mention the equal, and, perhaps, prior claim of Dr. Watson, to whom I have before said it had occurred. Dr. Watson showed a series of experiments to confirm the doctrine of *plus* and *minus* electricity to Martin Folkes, Esq., then president, and to a great number of fellows of the Royal Society, so early as the beginning of the year 1747, before it was known in England that Dr. Franklin had discovered the same thing in America. (See the *Philosophical Transactions*, vol. xliv, p. 739; and vol. xlv, pp. 93–101.) Dr. Franklin's paper, containing the same discovery was dated at Philadelphia, June the 1st, 1747.
>
> According to this theory, all operations of electricity depend upon one fluid *sui generis*, extremely subtle and elastic, dispersed through the pores of all bodies; by which the particles of it are as strongly attracted, as they are repelled by one another.
>
> When the equilibrium of this fluid in any body is not disturbed; that is, when there is in any body neither more nor less of it than its natural share, or than that quantity which it is capable of retaining by its own attraction, it does not discover itself to our senses by any effect. The action of the rubber upon which an electric disturbs this

[15] Watson, *Phil. Trans.*, abridged, **10,** 368 (1744–1748).

[16] *Loc. cit.*, **2,** pp. 26–27.

equilibrium, occasioning a deficiency of the fluid in one place, and a redundancy of it in another.

This equilibrium being forcibly disturbed, the mutual repulsion of the particles of the fluid is necessarily exerted to restore it. If two bodies be both of them overcharged, the electric atmospheres (to adopt the ideas of all the patrons of this hypothesis before Mr. Aepinus) repel each other, and both the bodies recede from one another to places where the fluid is less dense. For, as there is supposed to be a mutual attraction between all bodies and the electric fluid, electrified bodies go along with their atmospheres. If both the bodies be exhausted of their natural share of this fluid, they are both attracted by the denser fluid, existing either in atmosphere contiguous to them, or in other neighboring bodies; which occasions them still to recede from one another, as much as when they were overcharged.

This theory was placed by Priestley alongside of a development of the two-fluid theory originated by du Fay with the statement:[17]

I have taken a little pains with this theory (two-fluid theory) because I have thought it had been, hitherto, much overlooked, and that sufficient justice had not been done it even by those who proposed it. For the future, I hope it will be seen to more advantage, and appear a little more respectable among its sister hypotheses; and then, *valeat quantum valere potest.*

This two-fluid theory was doomed to be superseded by Franklin's theory.

The study of electricity then reverted more or less in the hands of Priestley during the years 1766 and 1767 to a study of the conductivity of more and varied kinds of substances, the criterion of conductivity being the ability to transmit a shock or as park. Innumerable compounds, both natural and synthetic, were investigated from this standpoint without there being recorded any evidence of a decomposition in any case.[18]

The next great discovery was in the field of "Animal Electricity" or Galvanism as it was later called. The following quotation gives the best idea of the then current idea of what Galvani had done.[19]

*Galvanism* is the name now commonly given to the influence discovered nearly eight years ago by the celebrated Galvani, professor of Anatomy at Bologna, and which, by him and some other authors, has been called animal electricity. We prefer the former name, because we think it is by no means proved, that the phenomena discovered by Galvani depend either upon the electric fluid, or upon any law of animal life. While that is the case, it is surely better to distinguish a new branch of science by the name of the inventor, than to give it an appellation which probably may, and, in our opinion, certainly does, lead to an erroneous theory.

All the experiments that have yet been made may be reduced to the following, which will give the otherwise uninformed reader a precise notion of the subject.

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[17] *Ibid.*, p. 52.

[18] This matter will be returned to later in another paper.

[19] The quotation is from an article on Galvinism contained in vol. 2, p. 73 of the "Supplement to the Encyclopedia, or Dictionary of Arts, Sciences, and Miscellaneous Literature," published in Philadelphia in 1803. The date of the discovery of Galvani is usually given as 1789.

Lay bare about an inch of a great nerve (of a frog), leading to any limb or muscle. Let that end of the bared part which is farthest from the limb be in close contact with a bit of zinc. Touch the zinc with a bit of silver, while another part of the silver touches, either the naked nerve, if not dry, or, whether it be dry or not, the limb or muscle to which it leads. Violent contractions are produced in the limb or muscle, but not in any muscle on the other side of the zinc.

Or, touch the bared nerve with a piece of zinc, and touch, with a piece of silver either the bared nerve, or the limb; no convulsion is observed, till the zinc and silver are also made to touch each other.

A fact so new, illustrated by many experiments and much ingenious reasoning which Professor Galvani soon published, could not fail to attract the attention of the physiologists all over Europe; and the result of a vast number of experiments, equally cruel and surprising, has been from time to time laid before the public by Valli, Fowler, Monro, Humbolt, and others.

The term "animal electricity" soon gave way to "Galvanism" in honor of its discoverer. Galvani believed that every animal organism was a source of electricity in some quantity, (*vide: torpedo, gymnotus electricus*, and *silurus electricus*) and that the vital processes were somehow linked intimately with this phenomenon. This theory was generally accepted until Volta, a professor in the University of Pavia, Italy, observed that when two metals and a liquid are combined to form a circuit, an electric current is produced, and further, that two different metallic wires are necessary to cause frog's legs to shudder and contract; the galvanic effect being extremely weak or absent entirely when only one kind of metal is used. All this led the way toward the discovery of the Pile of Volta, reported in 1800.[20]

[20] *See* "Primary-Cells—A Brief Historical Sketch," by C. J. Brockman, THIS JOURNAL, **4**, 770–80 (June, 1927).

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**Motion Picture Films.** The Bureau of Mines has available a number of motion picture films designed to illustrate the manufacture and proper utilization of motor gasoline and lubricating oils. The latest of these is entitled "The Power Within, or the Construction, Operation, and Care of the Internal-Combustion Engine," and is designed to familiarize the general motoring public with methods for the proper care and operation of the internal-combustion engine, thus tending to conserve the supply of the raw materials from which gasoline is derived.

The bureau's latest addition to its motion picture library is "The Heat Treatment of Steel," made in coöperation with one of the large automobile manufacturing companies. This film shows that 1475 separate steel parts of a typical automobile must be given special heat treatment, forcibly illustrating the importance of this process in the automobile-manufacturing industry. Old-time methods of tempering steel are shown in sharp contrast with the various steps in modern heat treatment.

Copies of these films may be obtained without charge, except for costs of transportation, from the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa.—*News Edition, Ind. Eng. Chem.*, **7**, 2 (Mch. 10, 1929).

# SELF-HELP FOR TEACHERS

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The live teacher is always seeking to improve in the practice of his profession. He looks continually for new avenues of development, for new ideas in teaching, for new methods of approach to difficult topics, for new demonstration, and laboratory material. As one thus endeavors to grow, it is a joy to find the viewpoint broadening and the grasp upon the subject becoming stronger and more comprehensive.

For teachers in the larger centers there are the afternoon, evening, and Saturday courses in various subjects. These and the annual summer school offer the progressive person ample opportunity for development. But there are many teachers in the smaller towns to whom most of the above advantages are not available. Even the summer school is often a formidable proposition, for to the amount of the bill for tuition at the distant college or university must be added the expense of room and board and the cost of travel which may often be a considerable factor. Unless some or all of these items are provided for by the local board of education (not likely in most cases) many teachers feel that they can ill afford the expense of a summer course.

If you are unable to carry on research because of insufficient preparation or inadequate facilities, do not be discouraged. At your very door lies a great opportunity. You can improve yourself if you so desire and do it in your own laboratory. All you need is the will to work and an allowance of half an hour a day. Steadily followed, this method will enable you to accomplish much and you will be surprised to find how easily progress is made. This is a statement of fact based upon experience.

Let any ambitious teacher select some topic which he wishes to study more in detail in order to acquire a wider knowledge of the subject and more skill in carrying out the work selected. Suppose, for example, you choose glass as your theme. Have you practised glassworking, cutting, fire-polishing, bending, sufficiently to feel that you are expert in such work? Have you ever done a really creditable piece of glass etching? Do you know how to silver glass? Can you demonstrate that ordinary glass can be made sufficiently soluble in water to give an alkaline reaction with phenolphthalein? What experimental work have you done with water glass?

Another fruitful topic is that of the preparation of compounds of the common metals. Starting with a chunk of malachite ore, could you prepare the various copper salts? Do you know by actual experience how to convert litharge into the numerous oxides and salts of lead? Have you ever prepared such simple substances as sodium nitrite, potassium sulfate, zinc chromate? Have you ever made such compounds as barium chloride, lead nitrate, sodium acetate, and others in 500-gram lots for

laboratory use? Are you familiar enough with the preparation of potassium iodate to direct a student who may desire to make some so that he can do the "wink" experiment? Would you know how to convert copper, which is insoluble in hydrochloric acid, into copper chloride? If you have not done these things, and many others like them, there is a lot of interesting work waiting for you. These preparations provide excellent opportunities for the extension of your knowledge of chemical reactions, and the procedures of solution, filtration, evaporation, and crystallization. The finished products, suitably preserved, may be put in the exhibition case for the edification of your students whose respect for your ability as a chemist will thereby be vastly increased.

If the common elements are already sufficiently familiar, there are the less common ones. What work have you done with chromium and manganese? Would you know how to convert chromium oxide into potassium chromate? Or the chromate into the dichromate? Have you ever prepared potassium permanganate? What work have you done with uranium compounds or the complex cobalt salts? How are barium ferrate and sodium tetrathionate made?

Perhaps organic chemistry may interest you more than inorganic chemistry. Have you prepared at your school such compounds as ethyl bromide, ethylene bromide, iodoform, acetamide, and others? What work have you done with the aromatic compounds? One needs only a good laboratory manual and a supply of common sense to be able to accomplish much.

If the simpler organic compounds are already familiar, there are the dyes, a most fascinating subject. Such coloring materials as Orange II, Bismark brown, resorcin green, naphthol yellow S, magenta, eosin, Meldola's blue are not difficult to make. One of my students is already making a series of dyes with good success and this is only his first year of chemistry. The work is therefore not beyond the capacity of any teacher of ability and determination.

Then there are the synthetic resins. Did you ever try to prepare any of them? It is easy to make a hard, insoluble solid of different colors from phenol and paraform. I do not say that the specimens prepared in my laboratory would pass inspection by the Bakelite chemists, but they are at least interesting and worth making; they provide an avenue of escape into a new field for the teacher who is weary of the tiresome repetitions of simple student experiments in the laboratory.

Colloids may interest you. Can you make solid alcohol and explain how it is formed? Do you know how to prepare a ferric sol? What experimental work have you done with rubber latex? How extensive is your knowledge of protective colloids, of Cottrell's process, of cataphoresis? Have you any first-hand experimental knowledge of ore flotation?

Textiles offer an attractive field for investigation. Can you analyze a sample of goods for wool and cotton? What dyes will not "take" on cotton? Do you understand the principles of union dyeing? What is an assistant, a leveling agent, a mordant? Could you dye three samples of wool yarn three different colors with alizarin?

If the electric current is available in your school, what work have you done with electroplating? Have you made white lead, iodoform, canarin, or potassium permanganate by electrolysis?

If you are teaching in a rural school, there is the field of agricultural chemistry. Have you tested the soil in the nearby cornfield for phosphates, nitrates, and potassium compounds? Do you know how to make the insecticides: kerosene emulsion, lime-sulfur, Bordeaux mixture, Paris green, lead arsenate? Could you analyze a sample of paint and determine whether its base was zinc or lead? Is the water in your neighborhood temporary or permanent hard water? Is there any starch in an apple, a cucumber, a beet? Have you done the Babcock test for cream in milk?

If you teach girls, then you have the field of household chemistry. Can you prepare baking soda by the Solvay process? Can you make good soap? Do you know how to prepare chemically pure salt? Have you tested the various brands of household ammonia for their relative values? Is there any phosphate in Oakite, or carbonate in Lux?

When your students know that you are working along advanced lines and see the samples you are frequently putting out, the effect upon them is very stimulating. Some of them may feel the urge to go a little deeper into the fascinating realm of chemistry. And as you advance, becoming more and more the master of your selected topics, you will feel a growing sense of power and confidence so that when some bright youngster wants to try work a little beyond that which the others are doing, you are all ready for him and can suggest interesting lines for him to follow as fast as his required experiments are out of the way.

The suggestions given above cover only a few of the many possibilities lying ready at every teacher's door. Get a good handbook of directions, pay out a dollar or two for chemicals not already in the school stock and go to work with a will. You will find the effort well worthwhile and the work fascinating, for you will learn much and enjoy a growing sense of mastery as you proceed.

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**Why Dividends Stop.** "I recently looked over the balance sheet of a large corporation that hadn't paid a dividend in ten years," says R. Perry Shorts, a banker, "I couldn't account for its poor showing until I finally learned that it had never spent a cent for research. Gradually its business had gone to pot, and it hadn't spent a nickel to find out why, or to create new ideas with which to meet the everchanging conditions of the times."—*Chem. & You*, **6**, 3 (1929).

# INDUSTRIAL MOTION PICTURES IN THE CLASSROOM

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With the increasing number of industrial films available on different processes, and with their growing use as auxiliary aids to the science courses, the value of these films in the chemistry classroom itself is of interest. With the view of estimating any benefit derived from the use of motion pictures of this type in classes, the following experiment was conducted. The results were estimated only by the word of the students themselves, but the replies received are sufficiently clear-cut to afford some definite conclusions.

The titles used are typical industrial films, made by the larger companies to illustrate their processes. Such films are usually available for mere payment of transportation charges through such agencies as the U. S. Bureau of Mines, Y. M. C. A. Film Bureau, University Extension Divisions, etc. A comprehensive list of such sources appeared within the past year in THIS JOURNAL.[1] The average total cost for transportation charges on the films used was $1.50 for each title.

The pictures were projected by a portable machine placed in the back of the classroom, all the films except one being on slow-burning stock. Requiring approximately fifteen minutes to the reel, there was ample time to change and show three reels in the sixty-minute class period, films being rewound by hand for the next class during the projection. However, two-reel pictures proved more successful, allowing time for questions immediately after the showing.

The films were scheduled in advance for the entire semester. They were chosen without having been seen and were therefore probably an average selection in their adaptability to chemistry classroom use. When possible, each film was shown as an introduction to the particular subject it was to illustrate. This tended to give definite form to the process in the student's mind, and enabled him to take part more intelligently in subsequent discussion. Upon completion of the series, the questionnaire which follows was given to the students in an attempt to measure results. The pictures were shown to four classes in chemistry, and seventy-five students gave replies. It is believed that the answers were not influenced by a desire for additional pictures, as the students were assured that the series was closed for the year.

## Questionnaire

The following motion pictures have been shown to chemistry classes this year. Recall each one carefully before you answer the questions below:

[1] "Motion Pictures for Science Classes," **5**, 1294–6 (Oct., 1928).

| Title | Reels | Shown in connection with: |
|---|---|---|
| "Beyond the Microscope" | 1 | Electrolysis of water; atoms and molecules |
| "A Trip through Filmland" | 2 | Photography |
| "Story of Steel" | 2 | Reduction of iron ores; manufacture of steel |
| "Oxygen, the Wonder Worker" | 3 | Claude process of liquefying gases; oxy-acetylene welding |
| "Jewels of Industry" | 2 | Carborundum and corundum |
| "Story of Dynamite" | 2 | Explosives and chemical energy |
| "Story of Gasoline" | 3 | Petroleum refining |

*1. Which picture did you enjoy most?* The choices were:

| | | | |
|---|---|---|---|
| Story of Dynamite | 36% | Story of Gasoline | 13% |
| A Trip through Filmland | 21% | Jewels of Industry | 7% |
| Story of Steel | 16% | Oxygen, the Wonder Worker | 4% |
| Beyond the Microscope | 3% | | |

*2. From which picture did you learn most?*

| | | | |
|---|---|---|---|
| Story of Gasoline | 32% | Story of Dynamite | 12% |
| Story of Steel | 21% | Jewels of Industry | 11% |
| A Trip through Filmland | 12% | Beyond the Microscope | 7% |
| Oxygen, the Wonder Worker | 5% | | |

*3. Which pictures enabled you to understand points which you did not otherwise understand clearly from the text and any class discussion?*

| | | | |
|---|---|---|---|
| Story of Gasoline | 40% | Story of Dynamite | 21% |
| Beyond the Microscope | 38% | Story of Steel | 20% |
| A Trip through Filmland | 21% | Jewels of Industry | 13% |
| Oxygen, the Wonder Worker | 7% | | |

*4. Which pictures, if any, did not add to your understanding of the subject as taken up by the text and any class discussion?*

Fifty-seven per cent replied that no pictures had failed to contribute to their understanding of the subject. Six titles were named by the following proportions of students:

| | | | |
|---|---|---|---|
| Oxygen, the Wonder Worker | 16% | Beyond the Microscope | 8% |
| A Trip through Filmland | 11% | Story of Steel | 7% |
| Jewels of Industry | 8% | Story of Dynamite | 4% |

One title, "Story of Gasoline" was not cited by any one as failing to contribute to his knowledge.

*5. What processes do you feel would have been more clearly understood if pictures of them had been shown?*

Of the seventy-five students replying, sixteen mentioned Glass, while ten named Silicates, referring to the same subject matter. Eleven named Methods of Obtaining Salts, five, Purification of Water, and five, Manufacture of Portland Cement. Six suggested Metallurgy (other than Iron). Fixation of Nitrogen, Coal, Cottrell Process, and Manufacture of Sulfuric Acid were also mentioned.

*6. Would you rather spend an hour seeing a picture and discussing it, or working an hour in laboratory? Why?*

Seventy-one per cent stated a preference for the picture, giving as reasons that it was more interesting, easier to understand, or stating a dislike of laboratory. Twenty-four per cent preferred laboratory, either on the basis of its being more interesting than a picture, or because of more lasting impressions from laboratory work and the write-ups following it. Five per cent liked pictures and laboratory work equally well.

*7. If you could do only one, would you rather take a trip through the refinery or see the picture "Story of Gasoline?" Why?*

This question was asked of twenty-four students who had just completed a tour through a large refinery, conducted by the chief chemist. They had also seen the picture. The students were asked to answer the question, not on the basis of general interest, but on a clear understanding of the refining process. Nine students, or 37.5% stated a preference for the motion picture, because the animated diagrams showed them interior operations that could not be seen in a trip through the refinery. Fifteen students, or 62.5% chose a visit to the refinery, giving as their reason the fact that questions could be asked and explained at any point during the visit.

*8. What criticisms would you make of the pictures which have been shown?*

The most common criticisms were:
Real chemistry of process not emphasized.
Too many pictures of buildings and grounds.
Too much complicated machinery shown.

*9. Neglecting their entertainment value, do you believe motion pictures have been of actual benefit to you in understanding chemistry? Why?*

Seventy-four of the seventy-five students answering replied "Yes." Some of the reasons which occurred frequently were:
They show practical applications of chemistry in industry.
Pictures take mechanical side while text takes up chemical side.
They show things which are difficult to imagine because unfamiliar.
Successive steps in a process are easily recalled from a picture.
Pictures leave stronger impression than the book.
They make the course more interesting.
Pictures break monotony of the course.
They make class discussion more real.
Greater detail given than in text.
Many points are explained which are not clear in the book. One strangely typical student answered "No" to the above question, preferring, he said, to spend an equal time with a "good book."

## Conclusions

*1.* As might be expected, the most interesting pictures were not the ones from which students learned most. In fact, the least popular on this basis stands next highest in clearing up points otherwise not clearly understood.

*2.* Apparently, high instruction value is generally sacrificed for high entertainment value in an industrial film and vice versa. No title is outstanding in both.

3. Some pictures appealed to only a small minority on any basis.

4. A majority of the students profited by all pictures. Some of the pictures benefited all, or practically all students.

5. Fuller understanding of some processes would have resulted through the showing of one or more additional films.

6. A majority of students prefer motion pictures to laboratory, but only because of less effort involved.

7. Some pictures may give a more thorough understanding of a process than an actual visit to the plant by the use of animated diagrams and cross-sections. Logical presentation and the omission of inconsequential details is also easier by this method.

8. Because they are designed for the widest possible use, industrial motion pictures cannot include involved technical points. However, these are readily filled in by subsequent discussion. The other objections are not serious ones.

9. The favorable student comments which are quoted under question nine are probably all valid. The author's net estimate of classroom motion pictures is decidedly favorable. Their best use is in connection with the "applied" portions of the course. They should be used in moderation and be chosen carefully, but are well worth, in any chemistry course, the moderate expenditure of effort and money which they cost.

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**Natural Sodium Compounds in 1928.** Production of sodium compounds, not including common salt, from natural salines and brines in this country in 1928, as indicated by sales or shipments by producers, amounted to 206,380 short tons, valued at $5,389,728, according to the United States Bureau of Mines. These figures include the output of sodium carbonate (soda ash), sodium bicarbonate, sodium sulfate (salt cake and Glauber's salt), trona, and sodium borate (borax and kernite), and show a large increase in both quantity and value as compared with 1927 partly on account of the continued development of kernite deposits.

The sodium carbonates reported were all from California and amounted to 79,830 short tons, valued at $1,578,256. They were produced from Owens Lake, Inyo County, by the Clark Chemical Company (product marketed as liquid caustic), Long Pine, the Inyo Chemical Company, Lone Pine (soda ash and sodium bicarbonate), the Kuhnert Syndicate, Bartlett (soda ash), and the Natural Soda Products Company, Keeler (soda ash, sodium bicarbonate, and trona), and from Searles Lake, San Bernardino County, by the Westend Chemical Company, Westend (soda ash).

The sales of sodium sulfate amounted to 6580 tons, valued at $42,485. Sodium sulfate (salt cake) was produced at Clarkdale, Ariz., by the Sodium Products Corporation; and at Wabuska, Nev., by the American Sodium Company. The 99 Company, at Okanogan, Washington, produced a small amount of sodium sulfate, but none was marketed. Hydrated sulfate (Glauber's salt) was produced at Casper, Wyo., by D. W. Gill.—*Chem. & Met.*, **36**, 445 (July, 1929).

# THE RESULTS OF CERTAIN EXPERIMENTS IN THE TEACHING OF CHEMISTRY TO COLLEGE STUDENTS*

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The evaluation of laboratory work in the natural sciences is a problem which is receiving considerable attention at the present time. It is a difficult one because of the variety of outcomes claimed at one time or another for this type of instruction. The logical procedure in attacking the problem seems to be that of measuring these outcomes, one at a time, with conditions so controlled that the only variable is the amount of laboratory work. It is the purpose here to report the results of such a study made with beginning courses in general inorganic chemistry at the University of Minnesota, during the fall and winter quarters, 1926–1927.[1]

One of the most important outcomes of any course, it is generally agreed, is the information or general achievement of the student gained through the course. It seems that the first step in justifying any teaching procedure would be to measure its effect upon achievement. If the particular method can be shown to increase this outcome, well and good. If not, we may still be able to justify it on other bases. The problem, then, was to measure

TABLE I

DATA FOR THE GROUPS TESTED AND COMPARED

| Group | College | No. of students | Prerequisite | Hrs. lect. per wk. | Hrs. quiz per wk. | Hrs. lab. per wk. | Credits per qtr. |
|---|---|---|---|---|---|---|---|
| I. | S. L. A. Chem. Eng. | 102 | H. S. Chem. | 3 | 1 (written) | 5 | 5 |
| II. | Eng. | 71 | H. S. Chem. | 3 | 1 (written) | 3 | 4 |
| III. | Eng. | 69 | H. S. Chem. | 3 | 1 (written) | 3 | 4 |
| IV. | Eng. Mines | 60 | None | 3 | 1 (written) | 6 | 5 |
| V. | Dent., Med. Pharm. Phys. Ed. | 154 | H. S. Chem. | 2.5 | 1 (alternately oral and written) | 3.5 | 4 |
| VI. | Agric. | 124 | H. S. Chem. | 3 | 1 (3 written, 8 oral, per quarter) | 5 | 5 |

* Paper read at Session on Educational Research in Higher Institutions, Section Q of the American Association for the Advancement of Science, New York City, December 27, 1928.

[1] The writer desires to take this opportunity to express his appreciation of the hearty coöperation and helpful criticisms of Prof. M. C. Sneed, Chief of the Division of General Inorganic Chemistry at the University of Minnesota, and of the members of his Division. Without this generous assistance, the study would have been impossible.

the effect of varying amounts of individual laboratory work upon achievement, keeping other factors constant when possible.

Six sections, made up largely of university freshmen, were the subjects. The essential data for these six sections are shown in Table I. It will be seen that all but Section IV had had chemistry in high school. It should also be noted that Section V had an average of 2.5 hours of lecture and 3.5 hours of laboratory per week. This is due to the fact that the weekly quiz hour for this group was taken alternately from lecture and from laboratory periods. All courses were two quarters in length. No two sections were lectured to by the same instructor, but all used the same text, Sneed's "General Inorganic Chemistry."[2]

Sections II, III, and IV used a briefer, more condensed laboratory manual[3] than that used by the other sections.[4] However, a careful comparison of these manuals showed them to be practically alike as far as subject matter is concerned. The manual for engineering students contains fewer but more comprehensive experiments. The Sneed and Kirk manual includes a greater variety of experiments, many more illustrations, and more detailed instructions to the student. The briefer manual is desirable for engineering students because they spend fewer hours in the laboratory.

Two measures of achievement were used in the experiment. Sections I and II were given the Iowa Placement Examination for measurement of previous training in chemistry, at the beginning of the course. At the end of the winter quarter they were given the same examination to measure the improvement which had taken place. Since high-school courses in chemistry have been shown by Koos[5] to differ very little in either content or method from beginning courses in college, and since none of the students in Sections I and II approached a perfect score even in taking the Iowa Placement Examination a second time, it would seem entirely legitimate to use this as a measure of improvement in these groups. The second measure of achievement was an objective test of 135 items devised for this experiment and based on the textbook and the common elements of the laboratory manuals. This test (hereafter designated as the Special Test) contained multiple choice and matching types of questions, names for formulas, formulas for names, tests on valence, writing, and balancing of equations and problems. This test had a reliability coefficient of 0.86 as obtained by

[2] Sneed, M. C., "General Inorganic Chemistry," Ginn & Co., New York, 674 pp., **1926.**

[3] Heisig, G. B., and Kirk, R. E., "Experiments in Chemistry for Engineering Students," Burgess, Brooke, Inc., Minneapolis, 56 pp., **1926.**

[4] Sneed, M. C., and Kirk, R. E., "Laboratory Manual of General Inorganic Chemistry," Burgess, Brooke, Inc., Minneapolis, 126 pp., **1926.**

[5] Koos, Leonard V., "Overlapping in Chemistry." The Junior College. Research Publications of the University of Minnesota. *Education Series*, No. 5, The University of Minnesota, Minneapolis, pp. 474–93, May, **1924.**

the alternate items method of self-correlation and use of the Spearman-Brown formula. The scores of 118 students in this test when correlated with their second scores in the Iowa Placement Examination yielded a validity coefficient of 0.71. This test was given to all of the six sections in March, 1927, at the end of the winter quarter. The data obtained by use of these two tests provided two lines of investigation. First, the six sections could be compared as groups on the basis of final achievement. Second, Sections I and II could be compared by matching individuals in Section I with individuals in Section II on the basis of available criteria. These were, percentile rank in intelligence tests, grades received in the fall and winter quarters of university work in subjects other than chemistry, and initial ability and training in chemistry as measured by the first score in the Iowa Placement Examination. The intelligence tests were the regular battery of tests (unpublished) taken by all freshmen when they enter the University of Minnesota. The grades used in matching were weighted in accordance with the values recommended by Wood.[6]

TABLE II

SPECIAL TEST RESULTS

| Group | No. of students | Range | Mean | Standard deviation |
|---|---|---|---|---|
| I | 102 | 78–133 | 108.04 ± 0.82 | 12.40 ± 0.58 |
| II | 71 | 73–123 | 106.32 ± 0.95 | 12.00 ± 0.67 |
| III | 69 | 78–122 | 106.01 ± 0.86 | 10.65 ± 0.61 |
| IV | 60 | 68–129 | 104.50 ± 1.12 | 12.96 ± 0.79 |
| V | 154 | 58–130 | 101.17 ± 0.79 | 14.55 ± 0.56 |
| VI | 124 | 53–131 | 96.61 ± 0.91 | 15.25 ± 0.65 |
| All groups combined | 580 | 53–133 | 102.96 ± 0.58 | 14.10 ± 0.41 |

The group comparisons based on Special Test results are shown in Table II. Inspection of these data shows some rather large differences, both among the groups and between each group and the combination of all of them. Throughout the study, differences are expressed in terms of their probable errors and the chances that the obtained difference is a true one. Any difference which is three or more times its probable error is regarded as a statistically significant difference. The significant differences obtained by group or section comparisons in the Special Test are shown in Table III. In this and following tables, the chances that the obtained difference is a true one, are expressed in terms of "per cent," based on tables of the normal probability surface.

The chances that the obtained difference is a true one are expressed in terms of per cent of the total area under the normal probability curve,

[6] Wood, Ben D., "Measurement in Higher Education," World Book Company, New York, pp. 74–80, 1923.

corresponding to distances on the base line between the mean and successive points of division laid off from the mean. These distances are obtained by dividing any given difference between two means by the probable error of that difference. Then, by reference to tables of the normal probability integral such as that given by Rugg,[8] the reliability of the difference may be obtained in terms of per cent of the total area for one-half the normal probability curve surface. Multiplying such a result by two gives the percentage based on the total surface for both sides of the curve. This may also be expressed as chances in 10,000 by moving the decimal point two places to the right.

TABLE III

STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN GROUPS

| Groups | Diff. betw. means | P. E. of diff. | Per cent | Groups | Diff. betw. S. D.'s | P. E. of diff. | Per cent |
|---|---|---|---|---|---|---|---|
| I-V | 6.87 | ±1.13 | 50.00 | I-VI | 2.85 | ±0.87 | 48.58 |
| I-VI | 11.43 | ±1.23 | 50.00 | II-VI | 3.25 | ±0.94 | 49.01 |
| I-all | 5.08 | ±0.90 | 49.99 | III-V | 3.90 | ±0.83 | 49.92 |
| II-V | 5.15 | ±1.24 | 49.74 | III-VI | 4.60 | ±0.89 | 49.97 |
| II-VI | 9.71 | ±1.32 | 50.00 | III-all | 3.45 | ±0.66 | 49.78 |
| II-all | 3.36 | ±1.03 | 48.60 | | | | |
| III-V | 4.84 | ±1.16 | 49.75 | | | | |
| III-VI | 9.40 | ±1.25 | 50.00 | | | | |
| III-all | 3.05 | ±0.94 | 48.53 | | | | |
| IV-VI | 7.89 | ±1.44 | 49.98 | | | | |
| V-VI | 4.56 | ±1.20 | 49.48 | | | | |
| VI-all | −6.35 | ±0.99 | 50.00 | | | | |

Table III shows significant differences between the means of Sections I, II, III, and those of Sections V and VI; also between the means of Sections I, II, III, and that of all combined, these differences being in favor of Sections I, II, and III; also, that the mean of Section VI is significantly lower than that of all combined. Between standard deviations we find statistically significant differences between the S. D.'s of Sections I and II and that of Section VI; between the S. D. of Section III and those of Sections V, VI, and of all combined. Section III is the most homogeneous and Section VI the most variable as well as the lowest in average achievement.

On the basis of these comparisons it seems that there are large differences in the achievement of these groups which could scarcely be accounted for by differences in instruction, intelligence, or amount of laboratory. It does not appear reasonable to suppose that a difference in means of 11.43 score points or 0.81 of a standard deviation could be accounted for by differences in the instruction or in the intelligence of these groups. It can certainly not be accounted for by differences in amounts of laboratory since

[8] Rugg, H. O., "Statistical Methods Applied to Education," Houghton Mifflin Company, New York, p. 391, 1917.

Sections I and VI between which this difference exists, had the same amount of laboratory. Again, Section III with only three hours of laboratory per week is almost as much superior to Section VI as Section I is. The correlation between achievement as measured by the Special Test and percentile rank in intelligence is 0.43 ± 0.04 and it does not seem probable that differences in intelligence between these respective sections would be great enough to explain such large differences in achievement. Neither is it likely that one section was much better taught than the others. The answer to the question probably lies in the realm of factors not measured in this study, such as aptitude and interest. This seems plausible since Section I is composed largely of students who are majoring in chemistry or chemical engineering, whereas Sections II, III, IV, V, and VI are composed of students who take these courses chiefly because they are required to do so.

In comparing Sections I and II, an attempt was made to eliminate some of the uncontrolled variables in the above-described comparisons. Students in Section II were all engineers, civil, mechanical, electrical, etc. These two sections had different instructors which does not seem to have been a very important factor. They used slightly different laboratory manuals, which has already been discussed. It seems likely also that Section II did not cover quite as much of the text as Section I. In all other respects, their instruction was as similar as might be expected under the conditions, the chief difference being that Section I had five hours of laboratory per week and Section II had three hours. In the writer's opinion all differences in materials and instruction favored Section I.

In Table IV are shown the data for pairs matched on the basis of the initial score in the Iowa Placement Examination. The results are expressed as actual gains, possible gains, and per cent of possible gain actually attained in the Iowa Placement Examination, and in terms of achievement as measured by the Special Test.

TABLE IV

RESULTS FOR PAIRS FORMED ON THE BASIS OF INITIAL SCORE IN IOWA PLACEMENT EXAMINATION—THIRTY PAIRS

| | Section I | Section II | Differences | P. E. differences | Per cent |
|---|---|---|---|---|---|
| In. score, Ia. Place | 90.0 ± 3.39 | 89.5 ± 3.26 | 0.5 | ±4.70 | 2.85 |
| Final score, Ia. Place | 130.1 ± 2.71 | 128.3 ± 2.96 | 1.8 | ±4.01 | 11.67 |
| Gain | 40.1 ± 2.52 | 38.8 ± 2.23 | 1.3 | ±3.36 | 10.21 |
| Possible gain | 98.0 ± 3.33 | 98.4 ± 3.23 | −0.4 | ±4.63 | 2.15 |
| Per cent gain | 40.9 ± 2.09 | 39.6 ± 2.01 | 1.3 | ±2.89 | 11.90 |
| Special test | 113.6 ± 1.29 | 106.6 ± 1.65 | 7.0 | ±2.09 | 48.78 |

The only significant difference, here, is between the means in the Special Test. This difference is a statistically significant one and favors Section I.

In Table V are shown the results for pairs matched in intelligence and average weighted grades. There are no significant differences in this case.

TABLE V

RESULTS FOR PAIRS FORMED ON THE BASIS OF PERCENTILE RANK IN INTELLIGENCE TEST SCORES AND AVERAGE WEIGHTED GRADES—NINETEEN PAIRS

| | Section I | Section II | Differences | P. E. differences | Per cent |
|---|---|---|---|---|---|
| P. R. intell. | 63.5 ± 4.69 | 63.6 ± 4.46 | −0.1 | ±6.47 | 0.27 |
| Grades | 5.25 ± 0.187 | 5.3 ± 0.190 | −0.05 | ±0.286 | 4.82 |
| Gain, Ia. Place | 44.2 ± 3.45 | 43.6 ± 2.29 | 0.6 | ±4.14 | 3.76 |
| Possible gain | 105.4 ± 4.43 | 104.0 ± 3.62 | 1.4 | ±5.72 | 6.43 |
| Per cent gain | 40.9 ± 2.26 | 42.9 ± 2.54 | −2.0 | ±3.39 | 15.21 |
| Special test | 110.0 ± 1.45 | 109.0 ± 1.67 | 1.0 | ±2.21 | 11.93 |

Eighteen pairs were formed matching individuals on the basis of intelligence and initial score in the Iowa Placement Examination. The results for these pairs are shown in Table VI.

TABLE VI

RESULTS FOR PAIRS FORMED ON THE BASIS OF PERCENTILE RANK IN INTELLIGENCE TEST SCORES AND INITIAL SCORES IN THE IOWA PLACEMENT EXAMINATION EIGHTEEN PAIRS

| | Section I | Section II | Differences | P. E. differences | Per cent |
|---|---|---|---|---|---|
| P. R. intell. | 67.4 ± 4.13 | 66.6 ± 4.04 | 0.8 | ±5.77 | 3.49 |
| In. score, Ia. Place | 92.8 ± 4.04 | 91.8 ± 3.71 | 1.0 | ±5.48 | 4.82 |
| Gain | 39.0 ± 3.56 | 41.5 ± 2.22 | 2.5 | ±4.19 | 15.46 |
| Possible gain | 95.1 ± 4.16 | 96.1 ± 3.67 | −1.0 | ±5.54 | 4.82 |
| Per cent gain | 40.0 ± 2.54 | 43.5 ± 1.79 | −3.5 | ±3.10 | 27.09 |
| Special test | 106.8 ± 2.24 | 112.0 ± 1.95 | −5.2 | ±2.96 | 38.11 |

These comparisons reveal an appreciable though not statistically significant difference between the means in the Special Test, favoring Section II. This is the only difference which has appeared in favor of Section II.

In Table VII, we have twenty-four pairs matched in average weighted grades and initial scores in the Iowa Placement Examination. We find here the second significant difference between means in the Special Test,

TABLE VII

RESULTS FOR PAIRS FORMED ON THE BASIS OF AVERAGE WEIGHTED GRADES AND INITIAL SCORES IN IOWA PLACEMENT EXAMINATION—TWENTY-FOUR PAIRS

| | Section I | Section II | Differences | P. E. differences | Per cent |
|---|---|---|---|---|---|
| In. score, Ia. Place | 90.2 ± 3.39 | 89.8 ± 3.14 | 0.4 | ±4.60 | 2.15 |
| Average grades | 5.62 ± 0.20 | 5.65 ± 0.18 | −0.03 | ±0.28 | 2.69 |
| Gain, Ia. Place | 42.4 ± 2.69 | 35.4 ± 2.19 | 7.0 | ±3.47 | 41.23 |
| Possible gain | 97.6 ± 3.39 | 98.3 ± 3.25 | −0.7 | ±4.73 | 3.76 |
| Per cent gain | 42.3 ± 2.06 | 36.3 ± 2.09 | 6.0 | ±2.97 | 41.34 |
| Special test | 113.7 ± 1.35 | 107.5 ± 1.77 | 6.2 | ±2.01 | 48.11 |

in favor of Section 1. The first one, it will be recalled, occurred with pairs matched in initial scores in the Iowa Placement Examination alone.

Finally, pairs were formed, using all three criteria in matching. The results for these are shown in Table VIII. No significant differences appear, although there are differences between the means in per cent gain in the Iowa Placement Examination and in the Special Test, both in favor of Section I. The differences are about as large as any others found, but lose significance because of the few cases involved, and consequent large probable errors.

TABLE VIII

RESULTS FOR PAIRS FORMED ON THE BASIS OF PERCENTILE RANK IN INTELLIGENCE TEST SCORES, AVERAGE WEIGHTED GRADES, AND INITIAL SCORES IN THE IOWA PLACEMENT EXAMINATION—NINE PAIRS

| | Section I | Section II | Differences | P. E. differences | Per cent |
|---|---|---|---|---|---|
| P. R. in intell. | 68.4 ± 6.83 | 67.2 ± 5.76 | 1.2 | ±8.19 | 3.76 |
| Average grades | 5.75 ± 0.27 | 5.65 ± 0.23 | 0.10 | ±0.35 | 7.48 |
| In. score, Ia. Place | 88.6 ± 6.02 | 89.0 ± 5.62 | −0.4 | ±8.23 | 1.08 |
| Gain, Ia. Place | 45.2 ± 4.68 | 41.0 ± 4.78 | 4.2 | ±6.69 | 16.20 |
| Possible gain | 99.3 ± 6.02 | 98.8 ± 5.62 | 0.5 | ±8.23 | 1.61 |
| Per cent gain | 45.7 ± 4.28 | 41.7 ± 2.59 | 4.0 | ±5.00 | 20.53 |
| Special test | 111.7 ± 2.6 | 107.3 ± 2.71 | 4.4 | ±3.78 | 28.49 |

All matched groups were also compared as to grades received in chemistry. Since the grades were given by two instructors, they were first equated in terms of their respective standard deviations. No significant differences in average weighted and equated grades were found.

In all matched group comparisons, the standard deviations were compared in every case. No significant differences in variability were obtained, but the group having the higher mean achievement in the Special Test had, in every instance, the smaller standard deviation. In terms of standard scores, therefore, the differences would become more significant than the obtained raw score differences.

## Conclusions

In conclusion it may therefore be said that two facts appear evident as a result of the study. First, there are significant differences between achievements of these sections, as measured by an objective test based on material included and taught in all the courses. Second, when two groups very similar in all respects excepting the amounts of time spent in the laboratory were compared as carefully as was found to be possible, the section having the greater amount of laboratory work showed consistent superiority in general achievement. The surprising and perhaps disappointing fact, at least to advocates of extensive individual laboratory work, is that these differences are not larger or more often significant.

Some of the defects of this study have already been pointed out. The two chief criticisms are inadequate control of variables other than the amount of laboratory work, such as previous training, different instructors, different emphasis in the various groups, etc., and failure to measure improvement as well as final achievement.

Further experimentation is now being carried on, in which an attempt is being made to remedy these faults.

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**Bones and Rare Stones Make Colors for New Money.** Lapis lazuli, a rich and expensive blue stone, was analyzed in order that ink of a similar shade might be used by the Bureau of Engraving and Printing in the color work on the new small-size money.

All the ink used for the intaglio printing and much of that used for surface printing is manufactured at the Bureau of Engraving and Printing by mixing dry colors, bases, oils, and other materials in large kneading mixers, which resemble those seen in large bakeries for mixing dough.

From these machines the ink is sent through mills between three heavy steel rollers under pressure so that the materials are well ground and amalgamated.

Barytes, the base for most plate inks, comprising about 30 per cent of the bulk of the ink used in the Bureau, is derived from natural sulfate of barium. It is mined chiefly in Missouri, where it is put through special milling machinery, crushed and ground to a fine powder and floated out on water, a process which produces a smoothness and texture suitable for making ink.

Dry colors purchased by the Bureau are made from coal-tar dyes, ground minerals, and chemical precipitates. More of the latter two are used at the Bureau on account of their permanency against light and atmospheric influence. The only aniline colors used are the reds, and those colors which contain red, such as purple, brown, and orange.

Chrome yellow made artificially is used for yellow. Chemically, it is chromate of lead.

The Prussian blue used is made from a great variety of substance; sometimes it is made from chemicals produced electrolytically from the nitrogen of the air. The ultramarine blue is made by calcining synthetically the constituents of lapis lazuli, a rich, blue stone.

For black, bone black is used—carbon made from calcined bones. Mineral blacks obtained from earth deposits are also used, likewise blacks as retort residues, found in various industries such as gas manufacture.

The green pigment used to make the green backs on all of the new money is a mixture of blue and yellow.—*Science Service*

**Chemicals No Help in Keeping Cut Flowers.** Don't put your cut flowers in a bath of aspirin or other chemicals in an effort to prolong their life. Experiments conducted at the Boyce Thompson Institute for Plant Research showed that none of 50 different chemicals, used in the hope of increasing the life of cut flowers, were noticeably effective. Potassium permanganate did prevent decay of the stems of phlox and asters but it did not make the floral parts last any longer. Other chemicals in some cases actually caused injury to the flowers.

Low temperatures were a great help in keeping roses, carnations, and coreopsis, but the cold did not greatly benefit either cosmos or dahlias. Humidity is also an important factor in keeping cut flowers. Carnations kept two to three times as long in an atmosphere which was nearly saturated with moisture.—*Science Service*

# THE STATUS OF CHEMISTRY IN TEXAS HIGH SCHOOLS AFFILIATED WITH THE SOUTHERN ASSOCIATION OF SECONDARY SCHOOLS[1]

GRETA OPPE, BALL HIGH SCHOOL, GALVESTON, TEXAS

Texas had a total of one hundred fifty high schools which were members of the Southern Association of Secondary Schools during the year 1927–1928, one hundred thirty-eight of which were public. In order to determine the present status of chemistry in the public high schools of Texas, a survey was made of these one hundred thirty-eight schools because they seemed to make up a representative group. The facts were ascertained from questionnaires that were sent to the various chemistry teachers who were teaching in these public high schools during the spring of 1928.

The aims of the investigation were to determine the status of chemistry with respect to the number of schools offering the subject and the number of pupils studying it; the training of the teachers and their teaching load; the methods and materials used in the teaching of this science; and the personal reactions of the Texas high-school teachers as to the existing obstacles in the teaching of chemistry, and the possible changes from present subject matter and method for making the teaching of this science more effective in Texas.

The following form of questionnaire was used in making the survey:

School Teacher

Degree

No. of years teaching chemistry

1. How many students do you have in chemistry?
2. Is chemistry required or elective?
3. How much science is required by your school for graduation?
4. What is the total enrolment of your school?
5. How many periods a week do you teach chemistry?

   Lab. Rec.
6. What subjects do you teach besides chemistry?
7. State the author of text and laboratory manual used.
8. Underline the nature of outside material used in your course: library references, local industries, community interests, individual projects.
9. Underline the obstacles, if any, that tend to limit the interest of chemistry students in high school: too much theory, unrelated to experience of the child, college entrance requirements, lack of library facilities, not enough laboratory equipment, any others.....
10. What changes from present subject matter and method would make chemistry meet the needs of high-school pupils more effectively?
11. Underline the source of your teaching preparation: State University, State Agricultural College, State Teachers' College, Denominational School, any others.....

[1] A thesis in partial fulfilment of the Degree of Master of Arts, New York University, October, 1928.

12. Underline any of the following chemistry courses you have studied: General, Organic, Qualitative, Quantitative, any others.....

13. Underline the courses in Education you have studied: Principles of High-School Teaching, Methods of Teaching Chemistry, any others.....

14. Name the subjects in which you have majored.

Teachers were asked to express themselves freely on any one of the topics. While many contributed valuable comments, some did not answer all of the questions; hence, the tabulated data varies as to the number of schools covered.

## General Conditions under Which Chemistry Is Taught in Texas

*General Data:*

TABLE I

| | Sent out | Returned | Giving chemistry | Not giving |
|---|---|---|---|---|
| No. | 138 | 85 | 75 | 10 |
| Per cent | | 61 | 88 | 12 |

Eighty-five or sixty-one per cent of the schools returned the questionnaires. Table I shows that seventy-five of the eighty-five schools offered chemistry as a part of their regular school work.

The schools were divided into four groups according to their enrolments as follows: (1) those having less than 250; (2) those having between 250 and 500; (3) those with an enrolment between 500 and 750; (4) those having more than 750 students. Table II is a tabular representation of the high-school students enrolled in chemistry in the schools accredited by the Association.

TABLE II

NO. OF REPLIES 70

| School group | No. of schools | Chemistry enrolment |
|---|---|---|
| Above 750 | 20 | 2135 |
| 500–750 | 11 | 408 |
| 250–500 | 21 | 635 |
| Under 250 | 18 | 371 |
| Total | 70 | 3549 |

Thus a total of 3549 students of seventy high schools were enrolled in chemistry during the spring of 1928. Tabulation shows that the high-school registration during this semester varied from seventy to twenty-one hundred, and the number of pupils enrolled in the chemistry classes ranged from five to three hundred twenty-five.

In reply to question 2, "Is chemistry required or elective?" seventy-one underscored elective. Six reported chemistry or physics required, and three alternated physics with chemistry. One school made Latin or science a requirement for graduation, while another reported four years of science required or two years of a foreign language.

Seventy answered the question, "How much science is required for graduation?" The results are as follows:

| Years | Schools | Per cent |
|---|---|---|
| None | 21 | 30 |
| One | 29 | 41 |
| Two | 20 | 29 |

## Training and Experience of the Chemistry Teacher

Another factor considered in this survey of Texas public high schools was the educational qualifications of the teachers of chemistry. It may be of interest to note that of the seventy-two teachers replying, thirty-two received the whole or a part of their training in denominational schools; twenty-three from state teachers' colleges; twenty-seven in the state university; ten in agricultural colleges; and thirty from more than one school. No less than seventy teachers among the seventy-three answers were holders of degrees. The distribution of degrees is shown in Table III.

TABLE III

DEGREES HELD

No. of Replies 73

| Degree | Above 750 | 500–750 | 250–500 | Under 250 | Totals |
|---|---|---|---|---|---|
| None | | | 2 | 1 | 3 |
| B.S. | 3 | 4 | 5 | 7 | 19 |
| M.S. | 2 | | 1 | | 3 |
| B.A. | 12 | 9 | 14 | 11 | 46 |
| M.A. | 4 | | 1 | 1 | 6 |
| Ph.D. | 1 | | | | 1 |
| Total | 22 | 13 | 23 | 20 | 78 |

A few teachers made mention of the graduate work they are doing. The following institutions were mentioned:

| | | | |
|---|---|---|---|
| University of Chicago | 7 | University of California | 1 |
| Peabody College | 2 | New York University | 1 |
| University of Oklahoma | 1 | Harvard University | 1 |
| Missouri University | 1 | Columbia University | 1 |
| Western State College of Colorado | 1 | | |

Information was sought also regarding the general training of the chemistry teachers. Ninety-six per cent of the teachers of chemistry in the spring of 1928 had had courses covering the general principles of high-school teaching; but only a small per cent, seven per cent according to tabulation, had courses in the special methods of teaching chemistry. This is not surprising, however, when we read the following excerpt:[2]

> Few Texas colleges offer advanced courses in science in their summer schools nor do any of them offer special courses in the teaching of the different branches of science.

[2] "The Teaching of Science," Dept. of Educ., *Bulletin*, No. **183,** 10 (Sept., 1924).

In 1925 there were only six colleges offering an education course in the "Teaching of Chemistry in Secondary Schools."[3] Two of these courses were offered in teachers' colleges. The Department of Education of the University of Texas offers no courses in the teaching of the various branches of science, although their program calls for such courses in other subjects as English, Spanish, and manual training. Some teachers do not think much of these courses in pedagogy, but I have found them very helpful. A chemistry teacher needs a broad training in pure science for the information it imparts, but he also must know what to teach and how to teach it. Our beginning teachers are frequently at a loss when thrown on their own resources in a laboratory.

The courses in chemistry which the teachers have studied are shown in Table IV.

TABLE IV

COURSES IN CHEMISTRY STUDIED BY TEACHERS REPLYING

Replies 72

| | |
|---|---|
| General, Qual., Quant., Organic | 45 |
| General only | 5 |
| No organic | 11 |
| Two courses | 11 |
| Physical | 15 |

All the teachers have studied general chemistry, and the above table indicates that forty-five or sixty-three per cent of the seventy-two have had general, qualitative, and organic chemistry. The following courses were also included in their special training: agricultural, industrial, household, and physiological chemistry; biochemistry, metallurgy, toxicology, and chemical engineering; food analysis and sanitation, colloidal chemistry, and organic synthesis.

TABLE V

MAJOR SUBJECTS

Replies 71

| | | | |
|---|---|---|---|
| Chemistry | 19 | Economics | 2 |
| Physics | 2 | Chemistry and Social Science | 2 |
| Sciences | 18 | English and Physics | 1 |
| Chemistry and Textiles | 1 | Science and Education | 4 |
| Chemistry and German | 1 | Education | 6 |
| Chemistry and Mathematics | 2 | Agriculture | 3 |
| Mathematics | 7 | Horticulture | 1 |
| Chemistry and Political Science | 1 | Entomology and Genetic Psychology | 1 |
| Total | | | 71 |

[3] "Survey of Chemistry in the Colleges of Texas," J. B. Entriken, THIS JOURNAL, 551–5 (May, 1926).

As to major subjects, the replies are quite varied. The majority, however, indicate a specialization in science subjects. These replies are tabulated in Table V.

Experience is another factor that enters into the teaching of any subject. Table VI is an attempt to show to what extent the teachers who taught chemistry in the public high schools of Texas during 1928 were experienced. The years of experience range from one to twenty years. The majority of teachers, however, have had five to ten years' experience. Those having more were connected with the large city schools.

TABLE VI

NO. OF YEARS TEACHING CHEMISTRY

Replies 61

| No. of years | Above 750 | 500–750 | 250–500 | Under 250 | Total | Per cent |
|---|---|---|---|---|---|---|
| 1 | | | 6 | 4 | 10 | 16.4 |
| 2 | | 2 | 6 | 2 | 10 | 16.4 |
| 3–5 | 1 | 2 | 2 | 5 | 10 | 16.4 |
| 5–10 | 10 | 2 | 5 | 4 | 21 | 34.4 |
| 10–15 | 4 | 1 | 1 | 1 | 7 | 11.4 |
| 15 or more | 2 | | 1 | | 3 | 5.0 |
| Total | 17 | 7 | 21 | 16 | 61 | 100.0 |

Chemistry teaching seems to be a man's job in Texas, for we find that men teachers outnumber the women. Of the seventy-two replies from the schools offering chemistry fifty-seven were men and fifteen were women.

Seventy-one schools volunteered information of the subejcts taught by the instructors of chemistry. The diversity of subjects that Texas teachers are required to teach is illustrated by the following tabulated data:

Chemistry and physics
Chemistry, physics, general science
Chemistry and biology
Chemistry, physics, biology, general science
Chemistry and general science
Chemistry, vocational agriculture, gen. science
Chemistry and agriculture
Chemistry, mathematics, agriculture
Chemistry and mathematics
Chemistry, physics, biology, mathematics
Chemistry, physics, general science, algebra
Chemistry, general science, mathematics
Chemistry, physics, botany
Chemistry, physics, physical geog., physiology
Chemistry, physics, physical geography
Chemistry, physical geography, general science
Chemistry, physical geography, algebra
Chemistry, physiology, home hygiene
Chemistry and zoölogy
Chemistry and manual training
Chemistry, physics, Spanish
Chemistry and economics
Chemistry and commercial subjects
Chemistry, commercial work, economics
Chemistry, physics, history, economics, foot-ball coach

The results are so varied that they are summarized as follows:

| | No. | Per cent |
|---|---|---|
| Full time devoted to chemistry | 13 | 18 |
| Time devoted to chemistry and physics | 11 | 15 |
| Time devoted to sciences | 30 | 43 |
| Chemistry teachers teaching subjects other than sciences | 17 | 24 |
| Total | 71 | 100 |

## The Methods and Materials Used in Teaching Chemistry in Texas

The methods and materials used in teaching chemistry in Texas are shown in the answers to questions five, seven, and eight. The replies to question five indicate that there is no agreement in the state as to the time that shall be spent on recitations and on laboratory work. The most common form of teaching procedure is the three periods per week of recitation and four of laboratory.

At the time of this survey, Texas was using a uniform text in her high schools; but in the spring of 1929 the textbook commission adopted a multiple list to be used over a period of six years, thus replacing the present text which had been in use since 1919. The state does not furnish a laboratory manual. In most instances, the manual used was the same as the textbook. Six schools reported manuals different from their texts, while three said they supplied their own laboratory directions.

The outside material used in the chemistry course was also asked for. The tabular representation of this information follows in Table VII.

TABLE VII

OUTSIDE MATERIAL

Replies 72

| | No. |
|---|---|
| Library references | 61 |
| Local industries | 58 |
| Individual projects | 31 |
| Community interests | 22 |

We may read:[4]

> The study of science should give a more intelligent appreciation of the services rendered to society by those individuals who are engaged in vocations of scientific nature and occupations based upon the applications of science . . . The topics should be chosen on the basis of their fundamental relation to life. . . . They should relate to local industries, community and school activities, and the life of the home.

It is evident from the teachers' remarks that Texas does appreciate the social implication of chemistry. Such replies as these indicate that the teachers as a whole are trying to make supplementary material an integral part of their work:

[4] "Reorganization of Science in Secondary School," *Bulletin* No. **26,** 14, 19 (1920).

Several weeks should be given to the chemistry of the natural resources in the section of the state in which we live.

A great deal of agricultural chemistry should be taught in most of our Texas schools.

Of all the gas in west Texas and oil in Beaumont and thereabouts, more attention should be devoted to community interests.

Much of our valuable teaching material comes from these sources.

Personally, I make an effort to link chemistry as closely as possible to local interests and conditions.

Our school attributes its large enrolment to their efforts to make chemistry practical.

I believe the use of the individual project is one of the most effective devices for teaching any science, and much valuable training is secured if each student knows that he is expected to be an authority on his particular interest.

Sixty-three responded to the question as to what obstacles, if any, limited the interest of the student in the chemistry class. Some replied that the interest was all that it should be, while others underscored the following obstacles given in the questionnaire:

TABLE VIII

OBSTACLES GIVEN

Replies 63

| Obstacles | No. |
|---|---|
| Too much theory | 34 |
| Not related to the experience of the child | 33 |
| Lack of library facilities | 14 |
| College entrance requirements | 8 |
| Lack of laboratory equipment | 7 |

In addition to the obstacles in Table VIII, the following were added to the list by the teachers themselves:

Not enough time for laboratory work
Lack of preparation in arithmetic and reading
Lack of preparation in 6th grade arithmetic
Not required for graduation, other electives easier
Lack of inclination to work
Lack of study
Poor teaching
Lack of a preparatory science
All students taking the same work
What others say about the course
The number of lazy, retarded pupils
Poor textbooks
State requirements
Notebook requirements
Beginning chemistry too difficult
Too much mathematics at the outset
Teachers overloaded, not enough time to prepare lecture demonstrations
The demand for highly polished furniture with smooth joints out of mill-run lumber

In commenting upon the obstacles, the teachers expressed themselves freely. Many of the teachers do not believe that theory bothers pupils provided their interest has first been aroused. The amount of theory possessed by some boys on radio is cited as an example. The greatest difficulty they think lies in presenting theories too early in the course.

They also feel that too many experiments are chosen and modeled by adults from their college courses without reference to what a child should know; hence, they are too often unrelated to the experience of high-school pupils.

Texas school authorities recommend a minimum laboratory equipment of $300 for each class of twenty students. Seven schools reported a lack of laboratory material. Fourteen mentioned the need of more library facilities. At a meeting of the State Teachers' Association, November, 1927, many of the schools reported themselves adequately equipped in this respect by laboratory fees; but most schools of the state require no fees or deposits (students paying only for their breakage), therefore, they are entirely dependent upon a kindly disposed school board. The State Department requires at least $400 worth of books well chosen for four-year high-school libraries; $300 for three-year high schools; and $200 for two-year high schools. It is recommended that the following constitute the library equipment for science:[5]

References: Suitable references for general agriculture, biology, nature study, invention, and discovery, and each physical science taught. Magazines.

The U. S. Bureau of Education[6] asserts:

A part of the requisite equipment of every chemistry department is a well-chosen set of reference books, available and in constant use, for he (the student) will profit by the training which comes from learning the answers to his questions from many sources of information.

Recognition was given in many instances to the American Chemical Society Prize Essay Contest and its set of reference books.

The teachers were asked to suggest ways and means of making chemistry teaching more effective in Texas. While only forty-three answered this question, nevertheless, the criticisms show that the teachers of Texas are aware of the problems confronting them. The constructive criticisms are tabulated in Table IX.

TABLE IX

NUMBER OF REPLIES 43

| Changes suggested | No. |
|---|---|
| 1. Better linking of experience with theory | 11 |
| 2. Connect laboratory work with life experience | 3 |
| 3. Less descriptive chemistry | 1 |
| 4. More interesting descriptive chemistry | 3 |
| 5. More modern supplementary material | 1 |
| 6. More practical material in textbooks | 12 |
| 7. Relate chemistry to industries, local | 16 |
| 8. Link chemistry as closely as possible to local conditions | 16 |

[5] *Bulletin*, **192**, pp. 72–5; *Bulletin*, **183**.

[6] *Bulletin*, **26**, 40 (1920).

| | Changes suggested | No. |
|---|---|---|
| 9. | More emphasis upon the preparatory courses | 2 |
| 10. | More training in the simple reasoning processes | 4 |
| 11. | More stress upon the fundamentals | 3 |
| 12. | Less material and far greater thoroughness | 3 |
| 13. | Distribute an even load throughout the year's work—too difficult at the beginning | 7 |
| 14. | Up-to-date textbooks adoption every five years | 12 |
| 15. | One-hour periods of teaching | 1 |
| 16. | Use of the project method to develop the spirit of science | 3 |
| 17. | Abandon the idea that high-school chemistry is to prepare for college | 6 |
| 18. | Separate the students into college and non-college preparatory students | 3 |
| 19. | Change the course from an abridged college course to one that fits the needs of high-school pupils | 6 |
| 20. | Minimum essentials for all students to eliminate overlapping in college | 2 |
| 21. | Different approach and reorganization | 37 |
| 22. | More flexible state requirements | 2 |
| 23. | Minimize the teaching load | 3 |
| 24. | Introduce technical terms as they are needed, not just for the purpose of teaching something | 12 |
| 25. | More time for individual work | 5 |
| 26. | Center the work around the laboratory work rather than around the text | 2 |

Summing up these criticisms, there are about five that are of greatest frequency. Eighty-six per cent desire a different approach and reorganization of material; thirty-two or seventy-four per cent suggest a closer relationship to local conditions and community interests; while thirty-one or seventy-one per cent are seeking more "practical" chemistry. Twenty-eight per cent offered criticisms upon textbooks, especially the one they were using. The texts adopted for the next six years received very favorable commendations. The criticism of the text in use was not entirely a criticism of the book itself, for it has been revised since 1919. It is rather a reaction against the length of time between adoptions.

One-hour periods of teaching were suggested as a more effective mode of teaching; but this did not meet the approval of all the teachers, the chief reason being given that sixty minutes were too short for laboratory purposes.

Other reactions which some of the teachers gave are particularly significant because they show the different educational values attached to chemistry. Some of these statements make interesting contrasts, particularly these two:

> For the ordinary high-school student, chemistry is largely a cultural course and should be largely descriptive. The strictly technical aspects should be taught in colleges to those who are planning to use it as a vocation. Chemistry is a specialized subject and as such should be relegated to technical schools. The average student who takes it in high school to get a unit of credit will never have any use for equations, chemical reactions, exact knowledge of properties, and formulas. Personally, I have

had a considerable amount of chemistry, both graduate and under-graduate work, but except for teaching it, it has never been of any use and I have forgotten the major portion of what I once knew. I don't believe you can make chemistry "practicable" for the average high-school student. It is now and, so far as I can see, will always be a highly specialized study and as such belongs to the curriculum of technical schools. Even its cultural value is doubtful. The average pupil who takes it for a unit of credit is wasting his time.

I try not to bore them with pure science for science sake, but endeavor to stimulate interest in the theory to the extent that they can intelligently interpret their daily experience as well as appreciate the every-day dollar and cent value of chemical information.

In a bulletin[7] on the teaching of science issued by the State Department of Education, we may read this warning:

A danger in the teaching of chemistry at present is the tendency to over-emphasize the practical phases of the subject. The mistake is often made of attempting to make the approach to new principles through practical applications of chemistry, an understanding of which often taxes the ability of the teacher. Many of the so-called "practical" applications are meaningless without a knowledge of the fundamental principles involved.

It appears to the writer that the fundamentals of science will make very little lasting impression unless they be approached through familiar things. There has been a tremendous amount of scientific information developed since the World War. Whose shall be the task of bringing the layman up to the point where he can appreciate this scientific information? If the public schools do not handle it, who will?

Professor J. O. Frank of the Chemistry Department of the Wisconsin State Teachers' College, suggests:[8]

that high-school chemistry be divided into three levels of subject matter—the *minimum essentials* which will be taught wherever chemistry is found; the *local essentials* which will vary with the nature of the community; the *near essentials* which will vary according to the class, the load the teacher is carrying, and the general conditions that affect the weakness or strength of the class.

Some teachers seem to favor an organization which includes college and non-college preparatory courses. Is this distinction valid or can greater efficiency be accomplished with the present organization by setting up the objective which Dr. S. R. Powers[9] declares to be the primary one of a high-school chemistry course, namely,

[7] "The Teaching of Science," Department of Education, *Bulletin* **183,** 10 (Sept., 1924).

[8] "Teaching First-Year Chemistry," J. O. Frank, author and publisher, Oshkosh Wis., p. 32, **1926.**

[9] "Some Problems of Curriculum and of Method of Instruction in High-School Chemistry," S. R. Powers, THIS JOURNAL, **2,** 1004 (Nov., 1925).

to impart such skills, abilities, knowledge, etc., as the field of chemistry may contribute which are useful in the affairs of successful men and women? Such a course will be well adapted for the accomplishment of training values and for college preparation.

Texas boys and girls entering Texas colleges and universities in almost every case start with students who have had no chemistry. Efforts have been made to discriminate, but these classes have been abandoned. Is this a reflection upon chemistry teaching in the high schools of Texas, or is it just proof that there is an urgent need for a critical examination of traditional methods and materials now used both in the high-school and in the first-year college chemistry courses?

## Summary and Conclusions

In summarizing the data as furnished by the questionnaire, the following facts are outstanding: a general dissatisfaction with the existing materials and methods of the chemistry course; a need for courses in the teaching of the various branches of science; teachers still required to handle too many subjects, especially in the small high school; a lack of preparation of students before taking chemistry; the tendency to introduce outside material into the course to make chemistry teaching more effective.

The suggested changes bring into focus the following conclusions: an urgent need for a critical examination of the materials used in the teaching of high-school chemistry and an earnest desire on the part of Texas teachers to reorganize the subject matter into more teachable units.

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**Lithium in Canada.** Lithium occurs in spodumene ore and also to a considerable extent in lepidolite with some amblygonite between the Winnipeg and Oiscau Rivers, east of Winnipeg. The deposits appear to be substantial, one of them being estimated to contain 30,000 to 40,000 long tons. Production so far has been experimental only, 60 tons having been produced in 1927 and about an equal amount in 1928. Two carloads were shipped to a glass company in the United States in 1927, and experimental shipments were sent to England. The demand for lithium from the glass, battery, and other trades has not been sufficiently great to cause development of these deposits in a large way. They are located near a large hydroelectric development at Points du Bois, and cheap power would be available for the extraction of lithium if demand for it should develop sufficiently.—*Chem. Age*, **20**, 449 (May 11, 1929).

**German Exports of Ammonium Chloride.** Exports of German ammonium chloride (35,580 metric tons) were nearly 40 per cent greater in 1928 than in 1927. This reflects to some extent the German efforts in various foreign markets to popularize ammonium chloride as a fertilizer to replace ammonium sulfate. The largest markets for this trade were Belgium (10,012 metric tons), France (9996), Netherlands (3689), United States (3509). Other countries purchasing smaller quantities were Great Britain (1906), Japan (1846), Argentina (571), and Canada (549).—*Chem. Age*, **120**, 445 (May 11, 1929).

# AN EXPERIMENT TO ILLUSTRATE THE LAW OF MULTIPLE PROPORTIONS

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The experiment which is used in most beginning chemistry courses to illustrate the Law of Multiple Proportions depends upon the thermal decomposition of potassium chlorate and potassium perchlorate. The experiment may be outlined as follows: A test tube containing a little manganese dioxide is carefully weighed, and about a gram of potassium chlorate is placed in it; after determining the weight of the chlorate by another weighing, the oxygen is expelled. A third weighing enables one to calculate the weight of oxygen that is combined with a definite weight of potassium chloride in potassium chlorate. The experiment is repeated, using potassium perchlorate, and the ratio of the two amounts of oxygen that are combined with a fixed amount of potassium chloride is calculated. There are several disadvantages to such an experiment: (1) it requires six weighings, which are very time consuming for a beginner; (2) the student is apt to become so involved in the calculations that he loses sight of the object of the experiment; (3) small experimental errors may lead to the ratio 4:5, or 2:3, instead of the correct ratio, 3:4. Another experiment which has been proposed to illustrate this law depends upon the reduction of the two oxides of copper. This leads to the simplest possible ratio, 2:1, but does not reduce the number of weighings or shorten the calculations. The difficulty in obtaining pure cuprous oxide is a serious disadvantage. This article describes an experiment which necessitates only three weighings, greatly simplifies the calculations, and involves the simple ratio, 2:1.

The following directions have been found satisfactory. In a dry hard glass test tube place about one gram of cupric bromide, and weigh the tube and contents accurately. Clamp the tube in a position slightly inclined to the horizontal, and fit it with a one-holed stopper (either cork or rubber) bearing a glass tube which dips into a flask containing a little water. The end of the tube should not dip below the surface of the water, but should end about one inch above it. Heat the cupric bromide in the tube, gently at first, then more strongly, until bromine fumes are no longer evolved. During this operation it is necessary to warm the upper portion of the tube somewhat, in order to prevent the condensation of bromine. When the tube has cooled, remove the stopper. Tilt the tube so that any bromine fumes which remain in it may escape, and weigh the tube and its contents. Now pour 2 cc. of concentrated nitric acid into the test tube, replace the stopper and delivery tube, and boil the liquid gently until all of the acid has evaporated, and the residue is dry and black. Replace the one-holed stopper by one having two holes; through one hole should pass a tube reaching a little more than half way to the bottom of the test tube, through the

other a tube which extends not more than half an inch beyond the inner surface of the stopper. Connect one of these to a hydrogen generator; when a test shows that all air has been expelled from the apparatus heat the material in the test tube until it is completely reduced to metallic copper. Allow the tube to cool, while the stream of hydrogen is still passing through it, and weigh it again. The data may be recorded in the following manner:

1. Weight of test tube and cupric bromide.....
2. Weight of test tube and cuprous bromide.....
3. Weight of test tube and copper.....
4. Weight of bromine in the cupric bromide.....
5. Weight of bromine in the cuprous bromide.....
6. Ratio of the two amounts of bromine (4 divided by 5).....

This experiment has been submitted to a group of sixteen students in general chemistry at the University of Illinois—three of them obtained very unsatisfactory results due to faulty weighing or spilling part of the sample; the other thirteen obtained ratios varying from 1.95 : 1 to 2.09 : 1, the average being 2.03 : 1. The directions as given to this class specified that the hydrogen delivery tube should reach nearly to the bottom of the test tube. In following these directions most of the students allowed the copper oxide to come in contact with the delivery tube, to which a little of it adhered. This error, which accounts for the high results obtained, may be avoided by following the directions given here. Some of the students completed the experiment in a two-hour laboratory period; most of them, however, did not quite finish it in that time. The time required for the completion of the experiment may be somewhat shortened if adequate ventilating facilities are provided for, in that case, the bromine and nitric acid fumes may be allowed to escape into the hood.

It will be seen that by weighing the empty test tube, the weight of copper may be found, and the experiment may be made to illustrate the law of combining proportions as well as the law of multiple proportions; if the tube is weighed after the ignition of the nitrate to oxide, the combining weights of copper and bromine may be calculated in terms of that of oxygen. It is difficult to introduce these additions, however, without obscuring the main point of the experiment.

The author wishes to express his indebtedness to Mr. Julius White for conducting the class experiments, and for several valuable suggestions.

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**Poison Bottles.** A special type of bottle for poisons, which cannot be mistaken even in the dark, is being produced in both England and Germany. The bottle is covered with sharp protuberances.

# A PRACTICAL APPARATUS FOR THE DESTRUCTIVE DISTILLATION OF COAL AND WOOD

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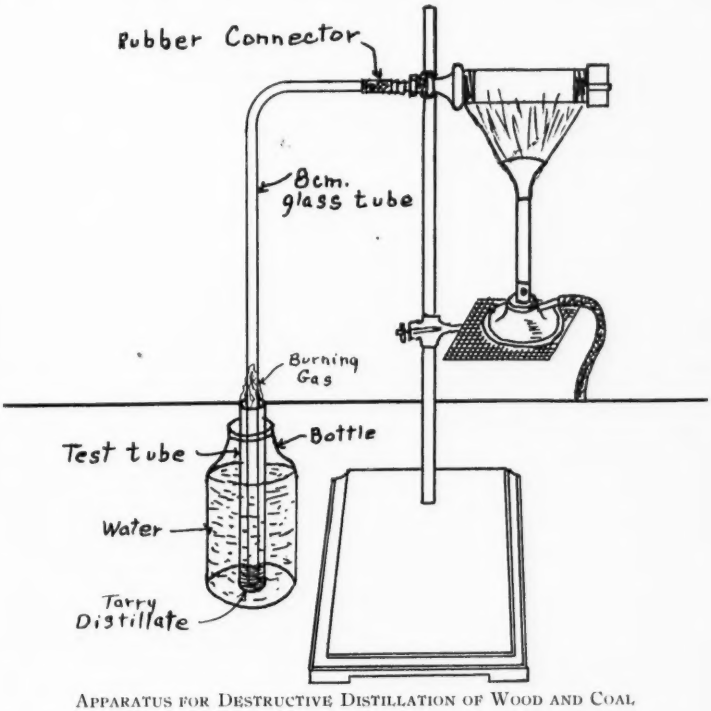
The usual type of apparatus that is used to show the process of destructive distillation is unsatisfactory. This apparatus consists of a hard glass test tube, fitted with a rubber stopper and a glass condensing tube. The high temperature necessary for the completed reaction usually melts

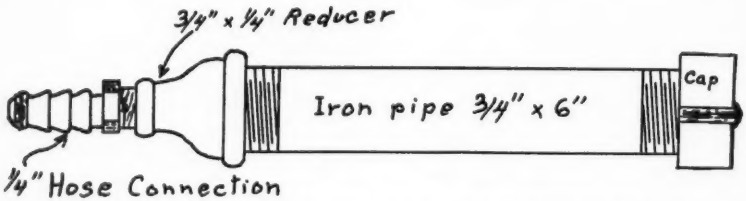



Apparatus for Destructive Distillation of Wood and Coal

the rubber stopper and very often breaks the test tube. Chemistry teachers know only too well the unsatisfactory results obtained with the old-type equipment, as well as the "muss" that always accompanies its use.

A satisfactory apparatus, that can be cheaply made, is shown in the accompanying diagram. All of the necessary material can be purchased at any plumbing shop for less than fifty cents. It consists of an iron pipe, $^3/_4'' \times 6''$, capped at one end and fitted with a $^3/_4'' \times {}^1/_4''$ reducer at the

other end. In the reducer is inserted a rubber hose connector. The condenser consists of a piece of 8-mm. glass tubing, bent at a right angle. The glass tubing should fit tightly against the metal hose connector, so




SHOWING DETAILS OF CONTAINER FOR CHARGE OF WOOD OR COAL

that no rubber is exposed to the decomposition products.

Some of the advantages of this apparatus are:

1. It is inexpensive, and can be reused many times. In the "test tube type" apparatus, the hard glass test tube is always spoiled for any other use, and it is almost as expensive as the first cost of the new type.
2. Can be easily taken apart, for loading, unloading, or cleaning.
3. Will withstand the temperature necessary for the decomposition of wood or coal.
4. Most important of all, it produces satisfactory results.

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**Dyes Test Seed Grain.** Dead or alive? That is the question thousands of agricultural laboratories in all parts of the world have to answer when testing seeds and grains. If the seed is dead, it will not germinate when sown. A new test devised by a Russian botanist, Dr. D. N. Nelubov, of Leningrad, will answer this important question in a few hours, instead of several days required by the ordinary methods.

Aniline dyes are used by Dr. Nelubov to tell apart seeds that are dead and alive. The seeds are steeped in a weak dye solution for three to four hours. Those able to germinate are not affected at all by the treatment, while the "dead" ones give themselves away by getting deeply colored. If seeds have hard husks they must be first broken, to enable the dye to penetrate to the embryo.

Not all aniline dyes are suitable for this work. Dr. Nelubov finds that the best results are obtained with indigo-carmine. About one-fifth of an ounce of the dye is required per one gallon of water.—*Science Service*

**Tree Seeds Sprout Best in Acid Water.** Acid soil has long been decried as bad farm land for so many years that it has come to be considered by current thought as no good for anything. It may, however, be as good for growing crops of wood as it is bad for growing crops of grain, according to results of experiments recently performed by Henry I. Baldwin of Berlin, N. H. Mr. Baldwin sprouted red spruce seeds in water of varying acidity and alkalinity. He found that slightly acid water was better than any of the alkaline waters. He got the best results in pure distilled water, which is perfectly neutral; but of course distilled water is never found under natural conditions.—*Science Service*

# THE SOLVAY PROCESS—A DEMONSTRATION

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In the past the writer has experienced some little difficulty in effectively teaching the "Solvay Process." This was no doubt due to the comparative complexity of the several equations necessary to bring out the process and to the fact that there was no successful demonstration to show the formation of the products. In a few laboratory manuals there are described experiments which are said to result in the precipitation of sodium bicarbonate but in these cases the action took too long and the result was far from impressive. Recently the writer undertook to study the process, making use of solid carbon dioxide. The results show that the industrial process cannot only be reproduced as a very effective demonstration but also as a successful laboratory exercise. Not only is the "Solvay Process" brought home to the student, but a large number of chemical principles may also be applied as will be shown. The directions are as follows:

Concentrated ammonium hydroxide is saturated with sodium chloride, filtered, and the clear solution poured into a cylinder or graduate whose diameter is about 2 inches. The cylinder should be about half full. To this are now added pieces of solid carbon dioxide, which may be obtained from the school lunchroom or nearby stores where ice cream is sold. The carbon dioxide proceeds to neutralize the ammonium hydroxide present and a copious precipitate of sodium bicarbonate is thrown down within ten minutes. If it is desired to completely precipitate the product, the carbon dioxide should be added until the odor of ammonia is no longer perceptible. The precipitate is then filtered and dried between filter paper. It can then be heated, at first gently, to drive off excess water and then decomposed to yield sodium carbonate and carbon dioxide. The latter is allowed to bubble through limewater and is thus identified. The sodium carbonate residue is tested with litmus to show its alkaline reaction and then tested with an acid to prove that it is really a carbonate. The filtrate containing the ammonium chloride may be evaporated and shown to be an ammonium salt by the usual test with sodium hydroxide.

The whole procedure can be easily carried out in a 45-minute period and can, if desired, very readily be done as a laboratory experiment.

The following advantages of this demonstration are apparent:

1. It reproduces an important industrial process on a laboratory scale. The student has the satisfaction of making something himself. He learns by doing, and retains the idea much better.

2. The experiment also illustrates the following chemical principles and thus aids as a fine review of previous work:

(*a*) Decomposition of a bicarbonate.
(*b*) Test for a carbonate.
(*c*) Test for an ammonium salt.
(*d*) Action of litmus on salts that are not neutral—*i. e.*, hydrolysis.
(*e*) The rules of solubility are admirably exemplified, namely, the insolubility of the sodium bicarbonate under the conditions of the experiment. Note here the low temperature produced by the "dry ice" and the saturated condition of the mixture which aids the precipitation.

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**"Impossible" Electron Movements Explain Cosmic Mysteries.** By the shifting of electrons in atoms in ways formerly thought impossible, cosmic mysteries such as the strange green lines in the spectrum of the northern lights are to be explained. So stated Lord Rayleigh, famous British physicist in his address as president of the section on physics and astronomy of the British Association for the Advancement of Science at its recent meeting at Cape Town, South Africa.

"In discussing the nebular and auroral spectra, we encountered the idea of 'metastable states,'" he said. "At present this conception is not in a very satisfactory condition. The original idea was of a state which did not allow of direct transition by emission of radiation to the stable ordinary state. Let us compare the level of the atom to the stories of a building and the optical electron to a man inside the building. The ordinary state of the atom is represented by the man being on the ground floor, and the metastable state by placing him on the first floor. But the internal architecture of our building must be pictured as peculiar. A staircase connects the first floor with the second floor, and another staircase connects the second floor with the ground floor: but there is no connection between the first floor and the ground floor except by going up higher and coming down again.

"Such, I say, was the original conception, but facts which have since come to light require some revision of it.

"In the nebulae the electron manages somehow to escape from its prison house, and descend to the level below not by the legitimate route of going upstairs and down again, but by illicitly breaking through the floor, contrary to the rules of the establishment."

In his own experiments, Lord Rayleigh has obtained spectral lines resulting from such "forbidden" changes.

On account of such experiments, he said, "It has even been proposed to define a metastable state as one with a low probability of transition. This takes us far from the original conception, and makes 'metastability' merely a question of degree. Some recent results which I hope to bring before the section at a later stage in our proceedings seem to indicate that even the normal excited state may possibly persist for a much longer time than has hitherto been supposed. If this conclusion is accepted, a far-reaching revision of our present notions may become necessary. The general softening of outline in our picture of atomic events resulting from the substitution of wave groups for particles seems likely to afford what is required, and to allow the occasional transition downward from a metastable state."—*Science Service*

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I like the man who bubbles over with enthusiasm. Better be a geyser than a mud puddle.—J. G. SHEDD

# A METHOD FOR SHOWING THE METALLIC LUSTER OF THE ALKALI METALS

W. CONARD FERNELIUS AND IMAN SCHURMAN, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

Every one who has cut a piece of sodium or potassium has undoubtedly been impressed by the bright metallic appearance of the freshly exposed surface and has regretted the almost instantaneous dulling of this surface due to the formation of oxide. The silvery luster of the alkali metals can be permanently preserved, however, by filling short lengths of glass tubing with these metals. A piece of tubing filled compactly with sodium or potassium has the same appearance that it would have if it were filled with mercury. Indeed, visitors to this Laboratory have frequently mistaken the alkali metals in such a container for mercury until they determined the lightness of the tube.

The process of filling glass tubing with an alkali metal is very simple and is described below. A piece of glass tubing about 20 mm. in diameter and 20 cm. long is drawn and sealed to a tube having a diameter 5–10 mm. and of any desired length. At the point of juncture *b* a constriction is made in the glass so that the diameter is near 2 mm. After thoroughly cleaning and drying this apparatus the end of the small tubing is fused shut at *c*. Sodium or potassium molded under benzene or kerosene into a cylinder or small balls and dried between pieces of filter paper is then dropped into the large tube. Sufficient metal is added so that when melted it will fill the slender tube—for 65 cm. of 6 mm. tubing, three of the common two-gram balls of potassium are sufficient. The upper end of the large tube is then carefully drawn down in a blast flame to a diameter of about 6 mm. By means of heavy-walled rubber tubing this tube is fastened to a vacuum line at *d*. This operation is perhaps best accomplished by the arrangement shown in the diagram.

A Y-tube with lower end at *d* is attached to a vacuum line through stopcock *e* and to a source of ammonia through *f*.

To fill the lower tube with pure alkali metal the following procedure is followed. With stopcock *f* closed and *e* opened, the system is evacuated.

After a good vacuum has been produced the apparatus is heated from *c* to the top of the enclosed metal until the metal is molten—both metals melt below 100°. The heating may be accomplished by a hand torch or by a furnace made by wrapping resistance wire around some glass tubing of sufficient diameter to surround the apparatus or, if the lower tube be short, by immersing the apparatus in a bath of melted paraffin or Crisco. With the metal molten, stopcock *e* is closed and *f* opened slowly. The ammonia pressure forces the pure liquid into the slender tube, impurities (oxide, hydroxide, etc.) being caught by the constriction at *b*.[1] Ammonia is not essential here, any relatively inert gas would do as well; even opening the stopcock to the air would be satisfactory although it is better not to use a gas which reacts readily with the metal.

This method of filling glass tubing with the alkali metals has been in use at Stanford University by Professor E. C. Franklin and his students for a number of years.[2] They used such tubes to introduce pure alkali metals into liquid ammonia solutions. Not only is the metal so added free from oxide and hydroxide but also the weight of metal for a given length of tubing is known. Provided the tubing has no great variation in bore diameter, it is easily calibrated by weighing a measured length before and after dissolving the metal in alcohol.

[1] Oftentimes it is desirable to place an iron nail or a short length of glass rod above the alkali metal to aid in breaking the oxide coating surrounding the metal.

[2] Bohart, a student of Dr. Franklin, describes a modification of this procedure [*J. Phys. Chem.*, **19**, 539 (1915)]. A similar technic employed in a different connection has been used by Dr. Kraus and his students [Kraus, *J. Am. Chem. Soc.*, **30**, 1206 (1908); Smyth, *Ibid.*, **39**, 1299 (1917); Peck, *Ibid.*, **40**, 337 (1918); Kraus and Lucasse, *Ibid.*, **43**, 2530 (1921); and other papers]. The same type of apparatus described in this article has been used to cast sticks of tellurium [Kraus and Chiu, *J. Am. Chem. Soc.*, **44**, 2002 (1922)], tin [Bergstrom, *J. Phys. Chem.*, **30**, 16 (1926)] and sulfur [Bergstrom, *J. Am. Chem. Soc.*, **48**, 146 (1926)].

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**Culture.** To be at home with those from all walks of life; to share the companionship of the great men and women of all literatures and of those who are near in the flesh; never to miss an opportunity of seizing upon a noble thought; to get understanding from children and wisdom from bees, birds, and flowers; to have ears that are open to the myriad harmonies of the world of nature and eyes that discern the manifold glories of the universe; to worship at the shrine of Beauty, be it enthroned in temple, grove, ripple of water, or haunting voice of woodland bird; to cherish the remembrance of kindness received and to pass it on to less fortunate than we; to have a heart so attuned to the infinite Compassion that no claim on it may be laid aside; to hate no man but all sin; to condemn no man unheard; to believe that the good in man's soul is but waiting to be roused by the challenge of trust; to be so endued with the spirit of patience as to abide steadfastly though humbly in the paths of righteousness and peace. —LINDA RIDER, *Educ.*, **49**, 570 (May, 1929).

# LECTURE DEMONSTRATION OF AMMONIUM AMALGAM

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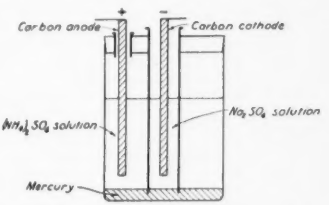
The most impressive evidence of the metallic nature of the ammonium radical is the formation of its mercury alloy, ammonium amalgam. A lecture experiment in frequent use, based on Sir Humphry Davy's method for making ammonium amalgam, consists in the addition of concentrated ammonium chloride solution to sodium amalgam in a tall cylinder. Upon stirring, the mercury swells up in a curious fashion, forming a spongy mass of about the consistency of butter. Whether the lecturer says so or not, the student usually assumes that this metallic froth is ammonium amalgam. This, however, is a debatable inference. According to Moissan,[1] ammonium amalgam prepared at low temperatures is about as dense as mercury. This suggests that the buoyancy of the product is due to gases enmeshed in the mercury. Such a view is supported by the work of Seely,[2] who studied the compressibility of the voluminous product, and found that under pressure it behaved like a foam. For reasons such as these, the frothy product is not conclusive evidence of the existence of ammonium amalgam. Moreover, the whole phenomenon might be explained as due to a surface reaction between the sodium amalgam and the ammonium chloride solution, which would be favored by the stirring and effervescence.




A more convincing experiment is the transfer of the ammonium radical through mercury by means of an electric current. A convenient form of apparatus (see Figure) consists of a beaker divided into two compartments by a tube dipping into a layer of mercury at the bottom. Ammonium sulfate solution is placed in the outer compartment, and sodium sulfate in the inner. Carbon electrodes are used, the anode being in the outer compartment containing the ammonium sulfate. A direct current, with a potential of about 10 volts, is used. After electrolyzing for five to ten minutes, the presence of ammonium in the inner compartment can be demonstrated by transferring a portion of the liquid to a beaker and adding sodium hydroxide solution. Now the ammonium group can reach the cathode only by diffusing through the mercury in the form of a dissolved metal, since ammonia and ammonium salts are quite insoluble in mercury. There may be considerable inflation of the mercury due to the decomposition of some of the ammonium groups in transit, but this would never account for the appearance of the radical in the cathode compartment.

[1] *Compt. rend.*, **133,** 806 (1901).

[2] *Chem. News*, **21,** 265 (1870).

# The Chemistry Student

## COOLING AND REFRIGERATION

OTTO REINMUTH, ASSOCIATE EDITOR

Refrigeration is, perhaps, more a matter of physics than of chemistry and, in its practical aspects, is certainly more the province of the engineer than of either the physicist or the chemist. Nevertheless, the principles involved are among those often employed by the physical chemist and even, to some extent, by the general chemist. At any rate, teachers of chemistry are frequently besieged by such questions as: "How can a refrigeration machine operate without any moving parts?" "How is it possible to cool a household refrigerator by heating it with a gas flame?" "What cooling medium is used in the Blank household refrigerator?" etc. We have, therefore, been led to believe that a brief review of the principles involved and of the means by which they may be adapted to practical problems of refrigeration might prove welcome to inquiring students and bedeviled instructors alike.

### Methods of Cooling

The simplest method of cooling consists in the interchange of heat between the object to be cooled and a *practically* unlimited supply of cooling medium which is available at a temperature somewhat lower than the final temperature desired. This is the method employed in cooling the ordinary laboratory condenser, where tap water acts as the cooling medium. It is also the method utilized by airplane and automobile engines, both air- and "water-cooled." Both types of engines are actually air-cooled; in the latter type water acts as an intermediate, absorbing heat from the motor and being in turn cooled by the air which is fanned through the radiator.

Numerous other methods of cooling are theoretically possible. C. W. Kanolt[1] lists the following (although not in the order here given):

1. *The Peltier Cooling.*—"The Peltier cooling is produced when an electric current is passed in the proper direction through a junction between two different metals. Under ordinary conditions difficulties in using this as a source of cold would be presented by the generation of heat as the result of resistance, and by the conduction of heat by the metals. The method has never been employed in practice,"[1] but has been suggested for use at extremely low temperatures.[2]

[1] "The Production of Cold," *J. Optical Soc. Am.*, **9**, 411–53 (Oct., 1924).

[2] Martin, *Chem. News*, **84**, 73 (1901); *Nature*, **64**, 376 (1910); **107**, 43 (1921); Swinton, *Ibid.*, **106**, 828 (1921).

2. *Cooling by Chemical Action.*—"An example of cooling by chemical action without the use of latent heats is afforded by a mixture of ammonium chloride and potassium nitrate in the form of powders, in the presence of a trace of moisture."[1]

3. *The Cooling of a Fluid by the Doing of Work in Expansion against an Electrical Force.*—"Meissner[3] has proposed to charge electrically the gas issuing from an expansion nozzle and cause it to carry the charge in a direction opposed to a restraining force, thereby diminishing the velocity and preventing part of the kinetic energy from being converted into heat."[1]

4. *The Conversion of Heat Energy into Kinetic Energy of Flow.*—If a gas could be caused to leave a chamber at a very high velocity, a corresponding amount of heat energy would have been removed from the gas and converted into mechanical energy and retained in this condition until the cold so produced could be utilized, in part at least. Nothing practical has been done along this line as yet.

5. *The Cooling of a Fluid by the Doing of Mechanical Work in Expansion against a Moving Mechanism.*—Students of thermodynamics will recognize this process as a reversed Joule cycle. (The Joule cycle bears somewhat the same relation to the Carnot cycle as van der Waals' equation bears to the perfect gas law.) Students who have never had the misfortune of encountering the Joule or Carnot cycles may content themselves by recalling that steam, introduced under pressure into the cylinder of a steam engine, loses heat not only by radiation through the cylinder walls but by converting some of its heat energy into work by expanding against the moving piston. A suitable refrigerant gas would, of course, act in the same manner.[4] This method is feasible in large refrigeration installations and has, in fact, been employed.

6. *The Joule-Thompson Effect.*—When a compressed gas is allowed to expand into a vacuum or into a lower pressure without doing any work, it produces a cooling effect merely by expansion. This principle is employed in the Hampson gas liquefier and also operates to some extent in the ordinary refrigeration machine—particularly the large installation of the compression type.

7. *The Absorption of Heat as Latent Heat.*—This includes heats of fusion, of solution, and of vaporization. We employ the former two when we freeze ice cream with the aid of rock salt and cracked ice, or when we use any of the ordinary laboratory freezing mixtures.[5]

[3] *Deutsch. phys. Gesell.*, **21**, 369 (1919).

[4] Such a gas would not lose any heat by radiation, since it would already be cooler than its surroundings. On the contrary, it would gain some heat through the cylinder walls.

[5] In the article already cited[1] Kanolt discusses a number of freezing mixtures and gives a table (p. 415) showing the temperatures which may be attained and the available cooling in gram calories per gram of mixture at various temperatures.

The melting of ice in an ordinary old-fashioned ice-box is an example of cooling by the absorption of heat of fusion alone. Cooling with "dry ice" or by means of a spray of volatile liquid is accomplished through absorption of heat of vaporization. The latter is also the principle to which all of the ordinary refrigeration installations owe a great part of their cooling effect.

## Types of Refrigeration Installations

Although the absorption of heat of vaporization is a process common to all industrial and household refrigeration devices, there is great variety in the means employed to put this process to practical use. Obviously, the problem to be solved is how to maintain a constant supply of fluid available for vaporization. Since all suitable fluids are expensive, it is impossible to allow them to escape into the atmosphere and to continually replace them with fresh supplies—even if we disregard the irritant, toxic, or inflammable characteristics which many of them possess. The problem therefore resolves itself into the necessity of devising practical means for reducing the vapor of the cooling medium to liquid form. The means which have been developed so far may be roughly classified under two heads—mechanical compression and absorption.

## Refrigerating Fluids

Refrigeration employing mechanical compression is so well known and so thoroughly understood by every one that there could be little point in undertaking a detailed discussion here. It may not be amiss, however, to include a note on refrigeration fluids.

"The choice of a fluid for refrigeration by the compression system will depend upon the temperature desired, the size of the installation, the thermodynamic properties of the fluids, the operating pressures they require, and upon their corrosiveness, their harmfulness when inhaled, their inflammability, and their cost.

"Industrially, ammonia is most used in large installations, and gives, in general, greater actual coefficient of performance than other refrigerants; sulfur dioxide is adapted to very small units, as in household refrigerators, because of the low pressures required, though ammonia is also used in small units, while carbon dioxide is especially suitable for use on shipboard or in other confined spaces where the accidental release of large quantities of ammonia or especially sulfur dioxide would be very dangerous to life."[1]

Table I[6] lists some of the properties of the more important refrigerants.

[6] This is a portion of a table included in the paper by Kanolt already cited.[1]

TABLE I

| Material | Critical temperature, Centigrade | Boiling point | Freezing point | Heat of vaporization at boiling point, calories per gram | Other properties |
|---|---|---|---|---|---|
| Ammonia | 132.4° | −33.4° | −77.0° | 327 | Harmful except in small quantities; corrodes copper and brass if not dry; not readily combustible. |
| Sulfur dioxide | 157.2° | −10.0° | −73.0° | 91(0°) | Harmful; corrodes copper and brass if not dry. |
| Carbon dioxide | 31.1° | −78.5° (sublimation) | −57.0° | 86(−57°) (liquid) | Nearly harmless, not corrosive. |
| Methyl chloride | 143.1° | −24.1° | −103.6° | 97(0°) | Anesthetic, inflammable, not corrosive. |
| Ethyl chloride | 183.0° | 14.0° | −142.0° | 83 | Anesthetic, inflammable, not corrosive. |

A recent note by *Science Service* touching upon the hazards associated with various refrigerants may be of interest here.

Deaths as a result of gas leaks from automatic refrigerators in Chicago recently are unlikely to be repeated very extensively elsewhere, in the opinion of government experts. Of sixty-three makes of electric and automatic refrigerators compiled in a recent list, only twenty-three make use of methyl chloride, the gas responsible for the Chicago fatalities, as a refrigerant. Of these, only one is a nationally advertised make. Furthermore, the only danger comes from central refrigerating plants, used in apartment houses, where the refrigerant is piped to a number of refrigerators throughout the building. Even when methyl chloride is used in a small independent home unit, a leak would not liberate enough of the gas to cause danger.

Sulfur dioxide, the choking gas that results from the burning of sulfur, is the most popular cooling compound, and is employed in the two most widely used electric refrigerators. While this is irritating to the nasal passages, it is not actually poisonous, in the strictest sense of the term. Its pungent smell is a safeguard because its presence is recognized before it reaches dangerous concentrations. Ammonia, used in many refrigerators, is safe for the same reason.

Methyl chloride is odorless, and, while it is not poisonous in itself, it *is* anesthetic and a large concentration would exclude the necessary oxygen, and death would result if a person were kept in a closed room with it. Many manufacturers use it in combination with either ammonia or sulfur dioxide, which have characteristic odors that reveal leaks. For a similar reason, manufacturers of illuminating gas, which consists largely of odorless and poisonous carbon monoxide, mix other gases with it that give the characteristic odor.

Carbon dioxide, which makes up a large percentage of our every breath, is used in one make of refrigerator. This is also the refrigerant used in cooling systems of battleships. For such purposes the other gases would be highly dangerous, because damage to the refrigerating ystem in a storm, or a hit by a shell in an engagement, would produce an effect similar to a well-placed gas bomb from an airplane.

## Absorption Systems

The earliest refrigerating machines were of the type where operation depends upon the absorption of the refrigerant gas.[7] For various reasons systems of the compression type overcame the early lead of the absorption cycle and are now by far the most numerous in practical use. The absorption system, however, has been the subject of a great deal of intensive research and of some highly ingenious inventive thought, and it is again coming into its own. It now bids fair to find application in certain special situations to which the better-known compression system has never been satisfactorily adapted, and even to supplant the latter in many instances. Each system has advantages peculiar to it, and future usage will no doubt be guided by the advantages which weigh most heavily in any given situation.

So far we have spoken of the absorption cycle as though it were as distinct a process as the compression cycle. This, perhaps, is misleading. As a matter of fact there are at least three different processes which are generally loosely classified as employing absorption cycles. One involves the solution of the refrigerant gas, generally in a liquid of relatively low vapor density. A second process depends upon the adsorption of the refrigerating vapor by means of a suitable adsorbent, such as charcoal or silica gel. Still another system employs as absorbents salts which form ammine- or addition-compounds with ammonia. All of these processes are actually in practical use today, though only the first has invaded the household field to any extent. Let us consider some examples in a little more detail.

## The Water-Ammonia Absorption Cycle

In principle the water-ammonia absorption system is exceedingly simple, "requiring but two pressure vessels with means for applying cooling water, a certain amount of piping, and no moving part . . . . ."[7] One vessel acts as an ammonia reservoir and evaporator and would ordinarily be placed within a refrigerator or other space which it is desired to cool. The other vessel contains water (or an ammonia-water solution) and serves alternately as an absorber and a generator.

To the best knowledge and belief of the present writer, the simplest and most compact apparatus of this type intended for actual practical operation is the "Icyball."[8] It consists, as shown in Figure 1, of a "hot ball" and a "cold ball," connected by piping. The "cold ball" is the evaporator; the "hot ball" acts as generator and absorber. The device is fitted

[7] Frederick G. Keyes, "Renaissance of the Absorption Refrigeration Cycle," *Ind. Eng. Chem.*, **21**, 477 (May, 1929).

[8] Described in the *Scientific American*, **141**, 245 (Sept., 1929).

to a small refrigerator cabinet, so that the "cold ball" is within and the "hot ball" remains outside.

"To charge the Icyball, it is lifted from the cabinet and stood on end so that the liquid all drains into the hot ball. Then, when the hot ball is heated, the ammonia is evaporated out of the water and is driven, as a gas, into the cold ball where it condenses. During this heating, the cold ball is immersed in a pail of cold water to expedite condensing of the ammonia. When the process is complete, the cold ball is inserted in the cabinet, the ammonia begins to evaporate rapidly because of its affinity for water, and the evaporation causes its temperature to drop to a very low point in the neighborhood of zero."[8]

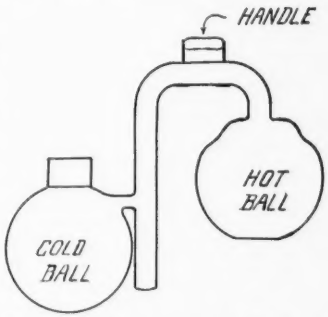



FIGURE 1.—DIAGRAMMATIC OUTLINE SKETCH OF THE "ICYBALL"

Gas, oil, coal, etc., may be employed as a source of heat. The fuel cost for one "charging" is said to be about two cents when gas is used, and one heating provides refrigeration and freezes ice cubes and desserts for twenty-four to forty-eight hours.

This device is intermittent in its operation, as were the earlier automatic outfits. For satisfactory automatic operation it would be necessary to add several accessories to this simple apparatus. These would probably include:

1. A water-cooled[9] condenser between the generator-absorber and the evaporator, so that ammonia would enter the evaporator in the liquid state.
2. A rectifier to prevent water from entering the evaporator.
3. A water jacket or other cooling device to cool the "hot ball" while it is acting as an absorber.
4. A controlled gas burner or electric heating unit which would operate while the hot ball is acting as a generator and cut out when it serves as an absorber.[10]

In order that such a cycle may operate continuously as well as automatically, further complications are necessary. The "hot ball" must be replaced by two separate vessels, one of which serves as an absorber and the other as a generator. Furthermore, the apparatus must be so designed that the following flows will take place in the desired directions:

[9] Air cooling is also a possibility and some devices employ it.

[10] An oil burner is also a possibility and has, in fact, been used, though not as yet on household units.

1. gaseous ammonia from the generator to the condenser and liquid ammonia from the condenser to the evaporator;
2. water (or ammonia-poor solution) from the generator to the absorber;
3. ammonia-rich solution from the absorber to the generator;
4. ammonia vapor from the evaporator to the absorber;

Figure 2[11] is a diagrammatic representation of a continuously operating automatic cycle. The patentees describe its operation as follows:

> The present invention relates . . . . to refrigerating systems of the kind including a generator, condenser, evaporator, and absorber wherein a cooling agent evaporates in the presence of an auxiliary agent, the auxiliary agent being introduced for the purpose of equalizing the pressure within the system . . . .
>
> As auxiliary agent, a substance is used which is insoluble or sparingly soluble in the absorption liquid, while at the same time condensable at ordinary temperatures. Moreover the auxiliary agent should be chemically inert with respect to the cooling agent. A substance filling these requirements when using ammonia as a cooling agent is propane . . . .
>
> The system operates as follows: Ammonia vapor is expelled in the generator K and is condensed to liquid form in condenser $C_1$. The liquid condensed in condenser $C_1$ flows into the evaporator in liquid form where it mixes with the auxiliary agent supplied thereto from condenser $C_2$. The auxiliary agent likewise enters the evaporator in liquid form. The liquid mixture thus collecting at the bottom of the evaporator is then evaporated. The conduits I and F open below the surface of the liquid in the evaporator and are filled with liquid so as to produce a liquid column pressure head exceeding the static pressure in the absorber and generator. An excess pressure is thus produced which forces gaseous fluid from the evaporator and through the absorber. Due to the liquid column retaining members I and F the gas mixture formed in the evaporator is caused to pass through a perforated plate P provided immediately above the gas inlet of the absorber. The gas mixture is thus distributed in the absorber and brought into close contact with the absorption liquid. In the absorber the cooling agent is absorbed by the absorption liquid and the auxiliary agent, is, so to speak, liberated and passes through conduit H to the condenser $C_2$ where it is again converted into liquid form. Absorption liquid enters the absorber through conduit B and flows downwardly therethrough in counter-current to the flow of gas therethrough and becomes enriched with the cooling agent. The cooling agent passes through conduit D and through coil X into the upper part of generator K. The coil X lightens the vertically extending body of fluid therein so that the specific weight of fluid within the same is less than the specific weight of fluid in the absorber and an automatic circulation of the absorption liquid is produced through the generator and absorber and through conduits B and D in the direction indicated by the arrows.[12]

As an example of how an actual working device may differ from a diagram necessary to explain its principles, we include Figure 3, showing two views of an embodiment of the same invention.

[11] von Platen and Munters (assignors to Electrolux Servel Corporation), U. S. Patent 1,678,277.

[12] The "lightening" of the ammonia-rich fluid within coil X is due to warming which expands it somewhat and at the same time liberates within it small bubbles of ammonia gas which lower the specific gravity of the mixture.

In these drawings: generator 50 corresponds to K of Figure 2; absorber 75 to A of Figure 2; evaporator 70 to G; condensers 65 and 85 of which 67 and 80 are the inner coils, respectively, replace $C_1$ and $C_2$, respectively; L is replaced by an outer

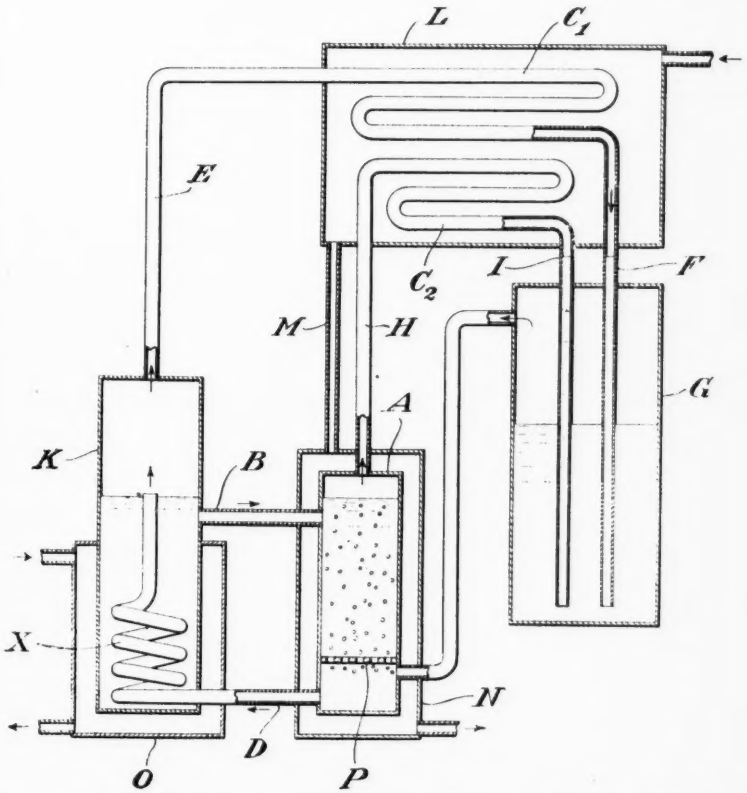



FIGURE 2.[11]—DIAGRAMMATIC SKETCH OF A CONTINUOUSLY OPERATING AUTOMATIC WATER-AMMONIA ABSORPTION REFRIGERATING CYCLE

K—Generator; A—Absorber; G—Evaporator; $C_1$—Condenser for ammonia vapor; $C_2$—Condenser for auxiliary agent (propane); L—Tank containing cooling water for condensers; M—Pipe connecting L with N—Water-cooling jacket for absorber; B—Conduit through which water (or ammonia-poor solution) flows from generator to absorber; D—Conduit through which ammonia-rich solution flows from absorber to generator; X—Heating coil in which specific gravity of ammonia-rich solution is reduced, causing it to enter above the level of the liquid in the generator; E—Pipe carrying ammonia vapor from generator to condenser; F—Pipe carrying liquid ammonia from condenser to evaporator; P—Perforated plate to insure thorough mixing of propane and ammonia vapors from evaporator with water in absorber; H—Pipe carrying insoluble propane vapor to condenser; I—Pipe carrying liquid propane from condenser to evaporator; O—Steam jacket for heating coil X and generator.

water conduit 66 with inlet at 69 and outlet at 71 and another outer conduit (unnumbered) with inlet at 49 and outlet at 91. The steam jacket O is discarded for an electrical heating unit 54 which fits into a well 52 let into the generator and welded to

the generator at 53. Coil 115 corresponds to coil X and discharges into the generator through conduit 116 above the liquid level 51. Conduit 56 corresponds to E, but a rectifier 55 is interposed to condense water vapor and return it to the generator. The rectifier comprises a series of baffles 59 inside the rectifier conduit 56. A series of cooling fins 57 having collars 58 serve to cool the rectifier. Evaporator 70 corresponds to G and conduit 45 to the unlettered conduit from the evaporator to the absorber in Figure 2. In this modification liquid columns in conduits 67 and 92, corresponding to F and I, respectively, are omitted and the condensers discharge directly into cup 93[13] at the top of the evaporator.

Interposed in conduit 92 is a gas chamber 125. The portion of conduit 92 which is connected to the evaporator is restricted at its connection with vessel 125 as indicated

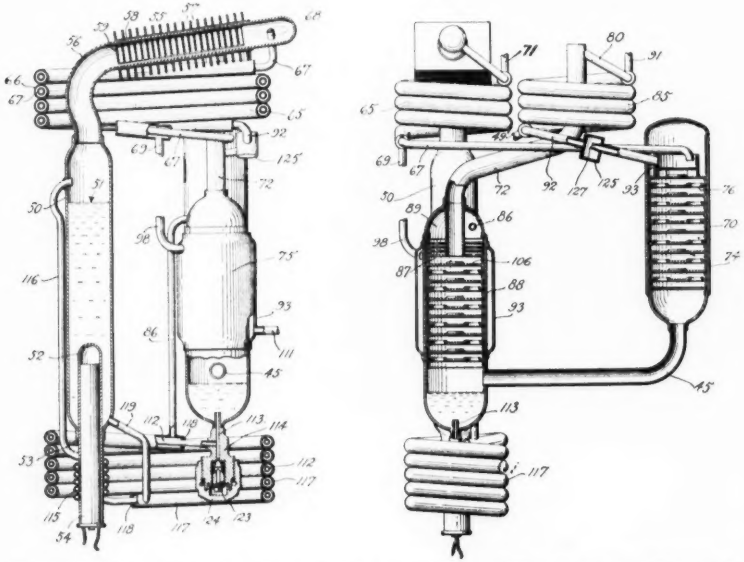


FIGURE 3.[11]—ONE PRACTICAL EMBODIMENT OF THE DEVICE DIAGRAMMED IN FIGURE 2

50—Generator; 75—Absorber; 70—Evaporator; 65 and 85—Condensers; 54—Heating unit; 55—Rectifier. For further explanation see text.

at 127. The purpose of this vessel is to force into the evaporator any vapor of ammonia which might pass into the propane condenser and which would not condense in the propane condenser. The gas assembles in vessel 125 and due to the restricted opening 127 alternating gas and liquid slugs are formed which serve to carry the gas entering between portions of liquid through conduit 92 into the evaporator.

The evaporator 70 comprises an outer shell 74 and a series of plates or discs over which the mixed liquid runs downward, evaporating as it goes. In the absorber 75 the mixed vapors enter above the liquid level and diffuse upward against a current of down-trickling water which enters through conduit 86 into a pre-cooling chamber

[13] The reader will note that 93 occurs twice in these diagrams. It is apparent from the context, however, which character is meant in each case.

89 and flows downward over a series of discs 106. The outer shell of the absorber is designated as 88 and surrounding this is a cooling water jacket 93,[13] corresponding to N, with inlet at 111 and outlet at 98. Insoluble propane passes through conduit 72, corresponding to H, to the condenser. The lower part of the absorber containing concentrated absorption liquid is connected with a conduit 112 (corresponding to D) through a passageway 113 in a filling member 114. Surrounding the major portion of conduit 112 is a conduit 117 which is welded to conduit 112 at the points 118. A conduit 119 connects the lower part of generator 50 with one end of conduit 117 and the other end of conduit 117 is connected to conduit 86 which enters into pre-cooling chamber 89. (This arrangement replaces conduit B in Figure 2.)

It is obvious that, although this particular design employs electricity for heating, the device could be modified to permit the use of gas. As a matter of fact, gas-operated machines are available, even in household sizes.

## The Salt Absorption Cycle

In discussing the water-ammonia absorption system we should not overlook the fact that other refrigerants and other solvents are possible. Methylamine might be substituted for ammonia and used with water. On the other hand, we might dispense with water entirely and employ as a solvent a solid salt in which ammonia is extremely soluble. (Ammonium nitrate is a good example.) It would seem that a system of this type might have to operate intermittently rather than continuously, but it would have the following advantages: (1) an absolutely non-volatile solvent, dispensing with the necessity for a rectifier; (2) the possibility of employing absolutely anhydrous ammonia which would permit the use of copper tubing in constructing the unit; (3) the use of a solvent which cools rather than warms during the process of solution—a distinct aid to efficiency.

So far as the writer knows, there are as yet no units of this type on the market. Dr. F. G. Keyes of the Massachusetts Institute of Technology has, however, taken out patents[14] covering the idea.

## Ammine-Compound Absorption Cycle

The ammine-compound absorption cycle operates in somewhat the same fashion as the one just described. Two salts which are suitable for use as absorbing agents are calcium chloride and strontium chloride, the former being preferable from the point of view of cost. This system also has the advantage of being able to employ anhydrous ammonia. It presents several problems, however.

Among the more important factors involved in using an ammine-forming salt may be mentioned the large volume change occurring when the ammine passes to the salt during the decomposition or heating part of the cycle, the maintenance of a desirable porosity to permit easy diffusion of the refrigerant throughout the material,

[14] U. S. Patents 1,258,017 and 1,267,772.

the avoidance of segregation in the material, and the elimination of the tendency of fine particles of the salt to be carried out of the generator by the rapidly moving gas stream. The material is characterized by poor heat conductivity and the design of the generator must be such as to permit a uniform heating of the ammine through the generating part of the cycle, as well as uniform cooling during absorption. If a good design is not realized, local overheating will (at 750°F.) gradually decompose the ammonia, resulting in a serious lowering of the efficiency of the refrigerating cycle . . .

The automatic control of the cycle of operations is the remaining portion of the task in realizing a long-lived, noiseless, and cheaply operated refrigerating unit. The cycle of operations to be automatically performed consists of the turning on of the gas (or electricity) at the moment that the refrigerant has been completely absorbed by the generator or, if the temperature of the refrigerator is sufficiently low, the turning on of the gas must be responsive to a temperature-controlled signal. In any event, at the instant the gas is lighted the cooling means must be transferred from the generator to the condenser. At the conclusion of the heating period, which must be timed to just empty the generator of its refrigerant content, the gas must extinguish and the cooling means transfer from the condenser to the generator, which now becomes an absorber.[7]

All these problems and others have been successfully and ingeniously solved and there are simple, reliable machines of this type on the market. Figure 4 is a diagram of one of the "Ice-O-Lator" units, which operates on this principle.

## The Adsorption Cycle

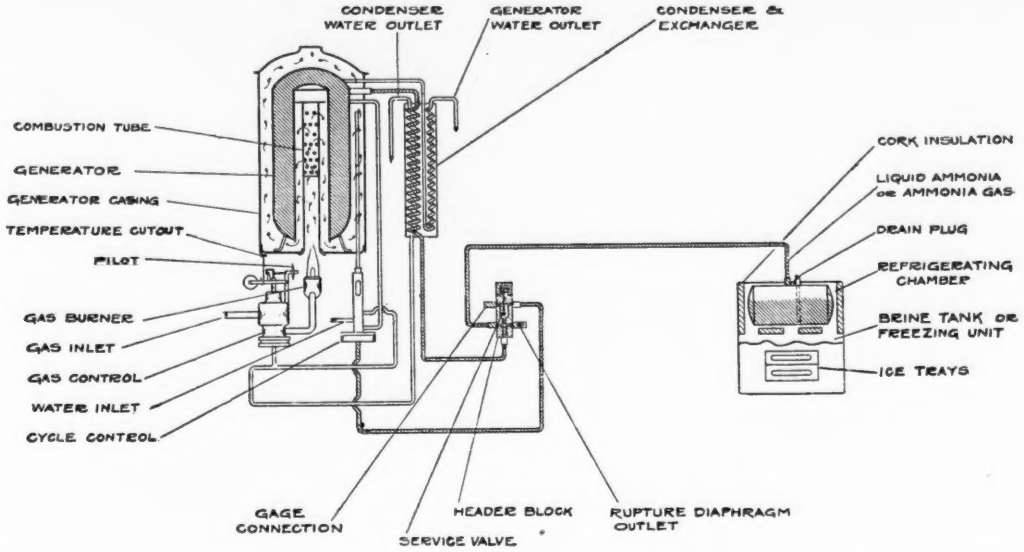
In the adsorption cycle the refrigerant is adsorbed in some suitable adsorbent material, such as charcoal or silica gel. The latter has been found to be especially well adapted to refrigeration needs. The adsorption machine operates by virtue of the fact that an adsorbed gas is held very tenaciously and at very low pressures. The application of heat increases the pressure and the gas may be driven out and condensed to be re-evaporated and re-adsorbed in the adsorbent.

An entirely successful system of this kind has been devised for the artificial refrigeration of freight cars and is described in detail by Hulse.[15] Silica gel is the adsorbent, and water vapor the refrigerating, medium, with liquid propane as a fuel supply. Obviously, this system must operate at a pressure considerably lower than atmospheric, in contrast to the systems already described which operate under pressures considerably greater than atmospheric. The action, is, of course, intermittent rather than continuous. Figure 5 is a diagram illustrating the very interesting apparatus described by Hulse. Household units are in process of development.

## Conclusion

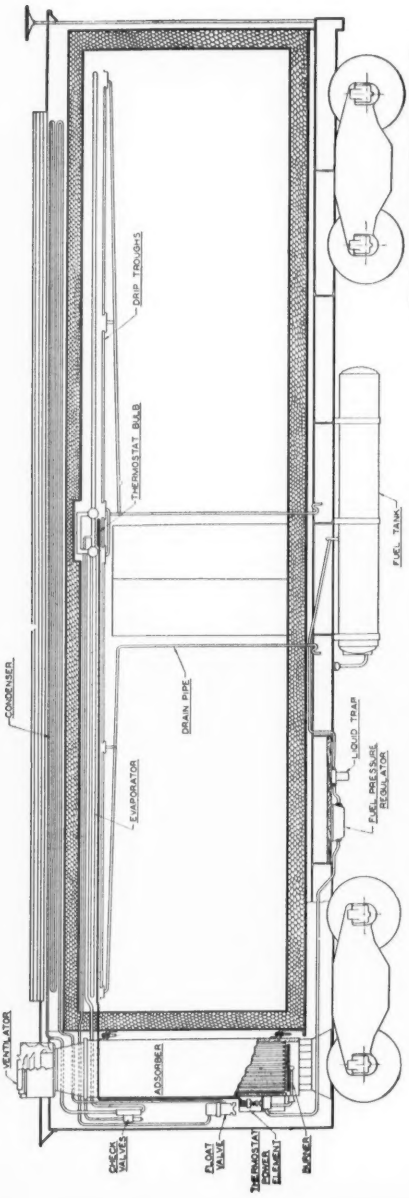
It has been claimed for the compression-type machine that it is more efficient than any of the absorption types.[1] However, the absorption systems have been tremendously improved of late, and the reader must

[15] Hulse, *Refrigerating Eng.*, **17**, 41 (1929).




Cut by courtesy of *Ind. Eng. Chem.*

FIGURE 4.—DIAGRAMMATIC DRAWING OF ICE-O-LATOR




Cut by courtesy of *Refrigerating Eng.*

FIGURE 5.—DIAGRAM OF REFRIGERATION EQUIPMENT IN CAR

also remember that the highest degree of thermodynamic efficiency is not always synonymous with lowest operating cost. Recent data[7] seem to indicate that a well-designed, gas-heated absorption system may be operated at a lower cost than an electrical compression system. Costs will naturally depend somewhat upon the respective costs of gas and current in any given community. Water costs and temperatures also enter into the picture with water-cooled machines. Aside from the matter of operating costs, the absorption systems are free from moving parts and, hence, presumably from wear and service costs, as well as from noise and vibration. In the latter respect, however, they have but little advantage over the latest models of the best electrical compression machines.

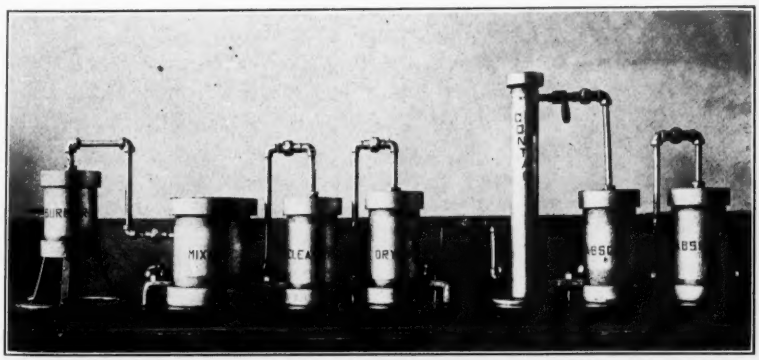
## Acknowledgment

In addition to the quotations and statements specifically accredited in the foregoing review, the writer acknowledges indebtedness for additional information to the sources already cited and to a lecture on "Adsorption and Its Relation to Refrigeration" delivered before the American Gas Association by Dr. F. G. Keyes.

# A MINIATURE CONTACT-PROCESS SULFURIC ACID PLANT*

S. C. DENNIS, GIRARD COLLEGE, PHILADELPHIA, PENNSYLVANIA

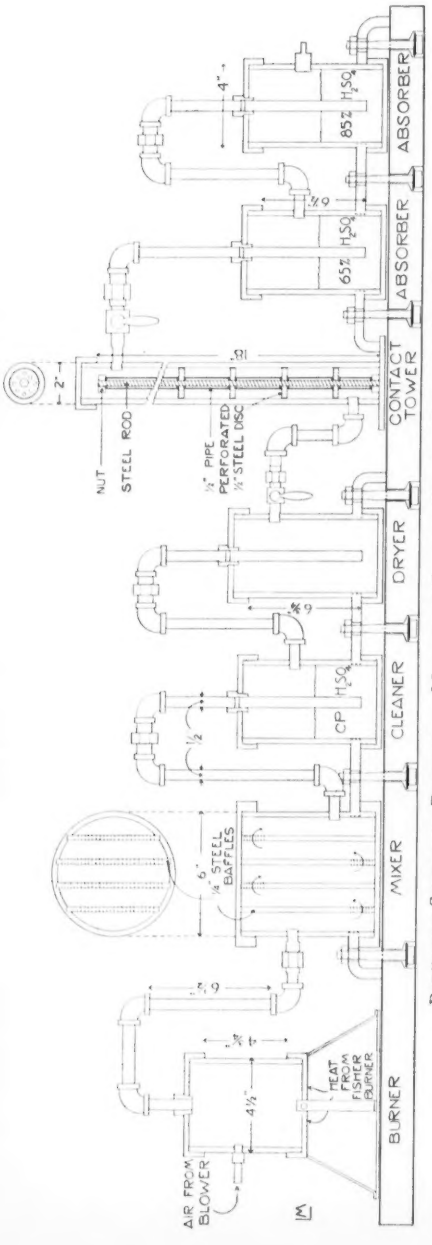
In preface to the description herewith presented, I may say that the industrial applications of chemistry have always been especially stressed in our courses at Girard College. As a means of awakening student interest along this line and of facilitating instruction in the solution of practical problems, our more advanced students are assigned projects dealing with commercial processes. These projects involve studies of the technical and scientific literature on the respective topics assigned and the preparation of reports which are delivered before the class. Drawings necessary for semi-works scale plants are made, and, finally, actual models of such equipment are constructed in the shops. With the exception of the fact that some of the actual construction work is done in regular shop time, these activities are carried on largely as extra-curricular and recreational projects. Naturally, student interest is an essential to the successful operation of such a program and a special effort is made to assign individuals to problems which particularly appeal to them.



THE ASSEMBLED PLANT
The blower, gas-burner, and electrical heating unit for the contact tower are not shown.

In our work, as in actual industrial practice, it often happens that the plant originally constructed leaves something to be desired in the way of successful and convenient operation. Hence, most projects do not automatically become "dead" after one assignment. Further research and development work is nearly always possible.

* *Editor's Note:* This article describes one of a number of models designed and constructed by Prof. Dennis' students, and is the first of a series of descriptions which he has agreed to prepare for us.




PARTIALLY SECTIONED DIAGRAM OF MINIATURE CONTACT-PROCESS SULFURIC ACID PLANT

## The Sulfuric Acid Plant

What I have just said is true of the sulfuric acid plant here described. Had I not the assurance of the editor that descriptions of models which offer opportunity for further development are equally as desirable as accounts of perfected apparatus, I should, perhaps, have hesitated to accede to his request for the preparation of the present article. In this account, therefore, I shall indicate some of the more outstanding improvements which would be desirable in the present apparatus.

## Materials and Details of Construction

The accompanying diagrams, together with the photograph, convey most of the essential facts as to dimensions and details of construction, so that it is scarcely necessary to repeat all such information here. A few additional remarks, however, may be helpful.

The containers are made of large-sized pipe of a good grade of cast iron, probably bordering on steel in composition and properties. The connecting piping is also of iron. Valves and fittings were all made by hand in our own shops.

The baffle plates in the mixer are of $^1/_4$" sheet steel, perforated alternately at top and bottom by a number of $^1/_4$" holes, as indicated by the dotted lines in the diagram. This design insures thorough mixing of the gases. The baffle plates are inserted into slots cut in the inner walls of the mixer.

The shelves in the contact tower are $^1/_2$"-thick discs of steel, perforated by $^1/_4$" holes. The shelving is designed so that it may be handled as a unit—as indicated in the diagram. The electrical heating unit for the contact tower is not shown. We are still experimenting with that, and with means for accurately determining the temperature at various points within the tower. It seems probable that we shall have to construct the tower of smaller pipe, before we shall be able to maintain it at the reasonably constant desired temperature of 400–450°C.

## Charging and Operation

At present the burner cannot be continuously charged. We have employed the rather unsatisfactory expedient of unscrewing the burner top, introducing a small charge of sulfur, and reclosing the apparatus. A better burner is now being designed.

Air for the burner may be furnished either from laboratory compressed air lines or from a motor blower. One of our students is at present repairing an old vacuum cleaner and converting it into a blower. Heat is furnished by a Fisher burner.

Acid is introduced into the cleaner and the two absorbers by removing the respective connecting pipes. When necessary these containers are drained by siphoning. We are now constructing valves to facilitate these operations.

The contact mass is prepared by spraying fused Epsom salts with platinic chloride solution and heating. Lumps of the material so obtained are distributed upon the shelves of the contact tower as they are lowered into place.

## Conclusion

All of the planning and construction work represented by this model was done by the students themselves, and further improvements are being worked out by them. There seems to be no reason why chemistry clubs or other groups, or even individuals, cannot work out similar miniature plants with little or no assistance from their instructors, if they are willing to undertake the necessary amount of really fascinating study, experimentation, and labor.

## STANDING CONTEST FOR UNDERGRADUATE STUDENTS

Continuing the custom adopted during the past scholastic year the Chemistry Student will offer each month an award of ten dollars to the undergraduate student who contributes the best article during that period. All other contributions deemed worthy of publication will be awarded prizes of five dollars each. Each monthly contest period will begin on the sixteenth of the calendar month and close the fifteenth of the following calendar month.

Papers on any of the following subjects may be entered in the contest:

1. A miniature chemical plant.
2. A chemical play or entertainment.
3. A chemical hobby or project.
4. An unusual and successful chemistry club activity.
5. How we make the programs of our chemistry club interesting.

Occasionally special awards may be made for exceptionally good papers which do not fall strictly within the scope of any of the subjects listed above.

### Directions for Contest

1. Type or write legibly on one side of the paper only.

2. If your paper lends itself to illustration, illustrate it with drawings or photographs or both. (As concerns illustrations observe the "Notice to Authors of Papers" which appears at the foot of the table of contents in the front of THIS JOURNAL.)

3. Mark each sheet of your manuscript and each illustration with your name.

4. On a separate sheet of paper give your name, your class, the name and address of the institution at which you are a student, the name of the chemistry club or fraternity at your institution, and the name of the faculty adviser or most active faculty member of your chemistry club.

5. Address contributions to: The Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Homewood, Baltimore, Md.

Contributions will be judged on the basis of:

1. Interest
2. Originality
3. Literary excellence
4. Excellence of illustrations (if any)
5. Neatness and legibility.

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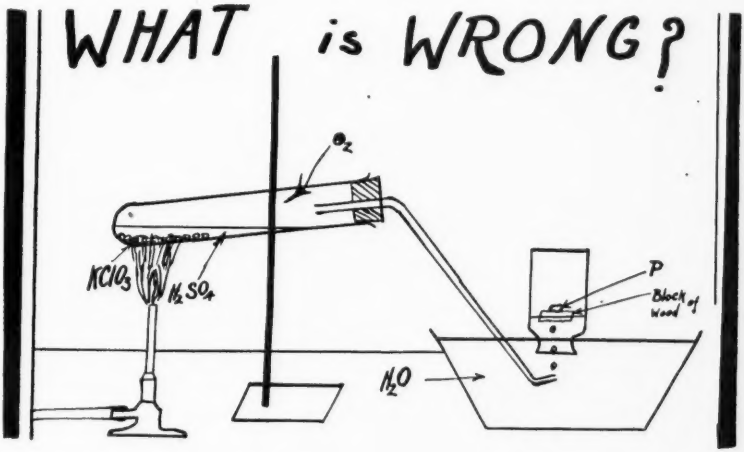
Sulfur in powder form is produced in Poland to the extent of 800 tons a year. The quantity used in the country is below this, and although the producers are urging its use in insecticides, the quality is so poor that consumers prefer imported material.

## A CONTEST FOR HIGH-SCHOOL AND FRESHMAN STUDENTS

On this page is reproduced a drawing prepared for us by Prof. John J. Condon of William Nottingham High School, Syracuse, New York. This picture is one of a series on laboratory set-ups and chemical reactions which will appear throughout the coming scholastic year. Each picture will be the basis of a contest for high-school and freshman students.

### Directions for Contest

Write a brief statement, telling what is wrong with the picture. Use complete sentences; do not merely list mistakes. Type your manuscript if possible; if not, be sure that you write legibly. Type or write on one side of the paper only.




Make a correct drawing, showing the picture as you think it should be. Use black India ink and white drawing paper. (If you believe that you can draw better on coördinate paper, white paper with blue rulings must be used.) Drawings should be approximately 4″ × 6″ or 8″ × 12″.

Place your name at the top of each page of your manuscript and at the top of your drawing.

On a separate sheet accompanying your manuscript write your own name, the name and address of the institution at which you are a student, the name of your chemistry instructor, and the name of the chemistry club at your institution (if there is one).

Address your paper to: The Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Homewood, Baltimore, Md.

Your contribution to this month's contest must be postmarked not later than October 15th.

### Awards

The best contribution received will be awarded a prize of five dollars and will be published in the December JOURNAL. The five next best papers will receive awards of one dollar each and the names of the winners will be printed in the December number.

Contributions will be judged on the basis of:

1. Correctness from a chemical standpoint
2. Neatness and correctness of drawing
3. English
4. Neatness and legibility of manuscript.

Papers which do not comply with all of the rules of the contest will not be considered.

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## AN ATTRACTIVE CHEMISTRY CLUB PIN

ORVILLE S. WALTERS, ENID HIGH SCHOOL, ENID, OKLAHOMA

The accompanying cut illustrates the pin designed and adopted for the Enid High School Chemistry Club, the "Alchemists." Initiation ritual and other details were given in the May, 1929, JOURNAL (pp. 958–62) in "A Successful Chemistry Club Initiation" (reprints obtainable from author).

The pin is of polished gold, and is one-half inch wide. It was obtained with a safety clasp at a cost of $1.30, made especially to order. In quantities, a lower price can be obtained.

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**Political Chemistry.** According to a United Press dispatch, Nicaragua has drafted chemistry as a political facility. The Nicaraguan National Election Board is to "mark" each voter at the next Presidential election. The marking will be done on the hand with chemicals, to prevent repeat voting.

The method of marking and the nature of the chemical that will be used have been withheld to prevent improper use of the information by either political party, says the dispatch.

To avoid creating a misunderstanding among ignorant voters, the election board has issued a statement explaining that the stain is harmless and will disappear in a few days.

Chemistry seems to be edging in everywhere these days. Can't even keep it out of politics!—*Business Chemistry*

# FRIENDLY FIRE*

ADELINE H. JACOBS, SIMON GRATZ HIGH SCHOOL, PHILADELPHIA, PENNSYLVANIA

The majority of disastrous fires would never occur if we did not have at hand, ready for instant use, a convenient and effective device for producing fires, namely, matches. One hundred years ago matches were unknown, and the making of fire demanded a certain degree of effort and skill.

The most primitive method of making fire is still used by the tribes of low culture of the South Sea Islands. It is much like the method that Camp-Fire Girls and Boy Scouts are taught—by twirling a pointed stick on a suitable piece of wood (Exp. 1). Likewise, the Australians and Tasmanian native tribes use two pieces of soft dry wood. One is a stick, a little less than a foot long, and the other piece is flat. The stick is somewhat pointed at one end. It is pressed upon the flat piece of wood and is revolved quickly between the hands. In two minutes, fire is produced, it is said. This instrument is called a "fire-drill." That term calls to our minds a very different picture.

Another primitive method of producing fire is that of striking sparks by means of a flint and a piece of iron pyrites, and allowing the sparks to fall on tinder (Exp. 2). This process was known to the ancients and they have handed down to us the name of one of the two materials used. "Pyrite" means literally fire-stone.

The old-fashioned tinder box, used until within a hundred years, is based on this principle. The box contained the tinder. Usually fastened to the box-lid was a piece of steel, placed in such a position that, when struck with a flint, the sparks resulting fell into the box and ignited the dry material within. This suggests the manner in which sparks, thrown out by a locomotive, will often ignite the dry grass bordering the railway tracks.

The Greeks were known to have produced fire by concentrating the sun's rays by means of a burning-glass or double convex lens, while the Romans used spherical mirrors to the same end. Tradition has it that Archimedes, the renowned physicist of the third century B. C., used this scientific means to fire the enemy's ships in the harbor during the siege of Syracuse. How readily a piece of paper becomes a mass of flames by this classic method! (Exp. 3.)

The beginning of the 19th century saw the invention of a friction match and its widespread adoption. One of the earliest types of match was invented just a hundred years ago. It was called the Cosgrove match.

* This paper is offered as a suggestion for a supplement to a Fire-Prevention Week program. The experiments contribute an enlivening element to an otherwise serious program. Other experiments than those indicated may, of course, be included.

These matches consisted of small sticks of dry wood dipped into melted sulfur, which hardened on cooling. The tip was coated over with gum, potassium chlorate, and sulfide of antimony. Such matches were ignited by being drawn through a fold of sandpaper. They cost about twenty-five cents a box of eighty-four matches. They were not generally used for several reasons. Of course the high price was one. Besides they did not ignite readily and, in addition, they produced very disagreeable fumes.

Phosphorus matches were first manufactured in Vienna on a large scale in 1833. About twenty years later, the first safety match was invented in Sweden. This was a great stride toward safety as, unlike the "strike-anywhere" match, the newly invented ones had to be struck on an especially prepared surface. The red or amorphous phosphorus is deposited on the box and not on the match head. Accordingly, safety matches cannot be fired on any rough surface, and accidental friction does not kindle them as it does ordinary friction matches (Exp. 4). Within the last hundred years the first United States patent was granted to a Massachusetts firm for the manufacture of friction matches.

White phosphorus, although no longer employed in match-making, is a highly inflammable substance. For this reason it is stored in bottles filled with water to keep it out of contact with air. It does not dissolve in water, but is soluble in carbon disulfide. When this solution of phosphorus is used like ink for writing characters on a sheet of paper, it is scarcely visible. But the liquid evaporates rapidly, leaving a fine deposit of phosphorus on the paper. In contact with air, the phosphorus takes fire spontaneously, with the result that characters written on the paper are left as a charred memorandum. We have heard of fiery-tongued orators whose words burned into the memories of their hearers. Here is a true fire writing, produced by using a solution of phosphorus in carbon disulfide (Exp. 5).

Water, as you all know, is the natural enemy of fire. Strangely enough, water will sometimes start a fire. Sodium is a silvery metal, so soft that it can be cut readily with a knife. When a small piece no larger than a tiny green pea is laid on filter paper nothing of note happens. But how differently the same bit of sodium behaves when it is dropped on wet filter paper floating in a dish of water. In a few seconds there is a bright flame (Exp. 6). Sodium liberates hydrogen from water and the heat of reaction is sufficient to ignite the hydrogen. It is rather astonishing to see that the paper on which the metal was placed is not burned, nor even charred.

Colored fires are used in parades at night, in fireworks of the rocket type, and in flare signals on railroads. Certain metals and their compounds impart special colors to a flame. The flame of the alcohol lamp

is almost invisible. When a little powdered strontium nitrate is sprinkled in the flame, it burns with a beautiful crimson color (Exp. 7). When some barium nitrate is used in the same way, the flame becomes green in color (Exp. 8).

Instantaneous photographs are made out-of-doors when it is bright and sunny. Indoor instantaneous photographs are also possible when the subject is brilliantly illuminated. For this purpose, a flash powder of magnesium is used. A narrow strip of magnesium metal produces an intense white light as it burns (Exp. 9).

With the light that has been thrown on the subject of friendly fire still in our eyes, our fire-prevention program of today is concluded.

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### CHEMICAL CANTOS

Sam put $AgNO_3$ in his ma's perfumery,
Thinking he would make a hit if he strengthened it a bit.
Now each morning little Sammy goes to greet his Coal Black Mammy.

Johnny, feeling life a bore, drank some $H_2SO_4$;
So his father, an M.D., gave him $CaCO_3$.
Johnny's neutralized, it's true, but he's full of $CO_2$.

Maudie was delighted when she found a lump of KCN.
"Daddy's fond of sweets," said she, as she dropped it in his tea.
Father drank it; that is how Maud's mamma's a widow now.

Tommy, eager to explore, found some $CuSO_4$.
"Nice rock candy," Tommy cried as he jammed a lump inside.
Doctor pumped him out, it's true, but Tommy still feels rather blue.

Bobbie, in his careless glee, mixed some I with $NH_3$.
When the stuff was dry and thick, Bobbie hit it with a brick.
Robert's now in heaven they say; at least he seemed to go that way.

Auntie Jane gave Baby Sue a dose of $HgCl_2$.
Baby's with the angels now, and Auntie Jane is wond'ring how
A single atom of Cl can make such change in calomel.

THOMAS STEPHENSON

Reprinted from the *News Edition* of *Ind. Eng. Chem.*, Aug. 10, **1929**.

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### WONDERS OF CHEMISTRY

Maud Muller, in this chemic day,
Far from the meadow sweet with hay,
Treats herself to a coat of tan
Out of a cute, convenient can.
Give her a can of tan, and soon
She has an August brown in June.
No more of looking broiled till fall,
No freckles, blisters, burns at all.

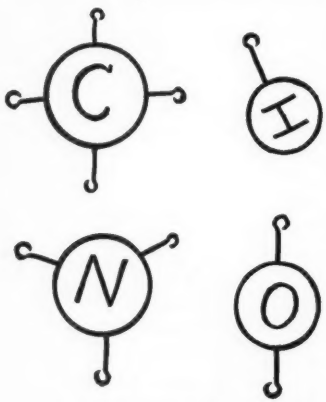
From the *New York Times*, via the *News Edition* of *Ind. Eng. Chem.*

# CHEMICAL BANK*

HOWARD JAMES, CROWLEY, COLORADO

Structural formulas, those invaluable aids to the organic chemist, constitute the basis of this game. The characters employed represent atoms of various elements and these are hooked together in the proper manner to form molecules. The characters are round, from one-half to three-quarters inch in diameter and one-quarter inch in thickness. They are cut from corks with a safety razor blade. Copper wires with hooks on one end are fastened into the sides, forming the valence bonds. The central disk is marked with the symbol of the atom it represents.

Each player has the following characters in his hand: 1 carbon atom; 1 chlorine; 2 oxygen; 1 nitrogen; 1 hydrogen; and 1 hydroxyl group. A common pool or "bank," from which each player may draw, contains atoms of the following elements: C, N, I, P, O, H, S, Br, and Cl; also such groups as OH, $C_2H_5$, and $CH_3$.

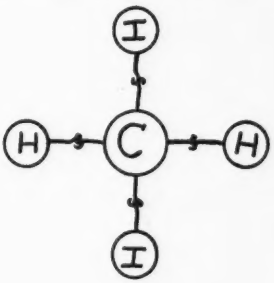


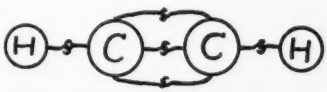

THE CHARACTERS MOST USED
Groups are made by uniting the proper characters.

The player who begins the game has an extra carbon atom in his hand. He synthesizes a simple compound, such as methane, by uniting together the proper atoms, which are taken from his own hand. Atoms he does not hold may be taken from the bank. For the size hand designated, the synthesized molecule must contain no more than two carbon atoms. The molecule must be one that can be produced either directly from its elements or from inorganic compounds by a definitely known reaction. If the original player builds a molecule that does not meet the above requirements, his opponent may call "Stop." The original player then loses his turn and must keep the extra carbon atom. Another method of starting the game is to construct any simple molecule from the atoms in the bank, regardless of the possibility of synthesis. Both hands should then, of course, be equal. The player who first disposes of all the characters in his hand wins the game.

* *Editor's Note:* Mr. James, who will be remembered as a previous contributor to the Chemistry Student, completed his freshman year at the University of Colorado last spring. The interesting game which he describes here may be used, as he suggests, for chemistry club contests or by classmates as a painless method of improving their knowledge of chemistry.

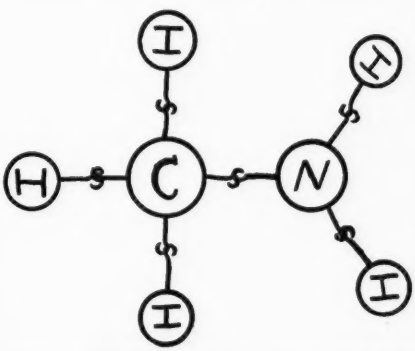
The play passes first to one contestant, then to the other. One move constitutes those changes necessary to alter the molecule in accordance with a definite and known chemical reaction. The player uses atoms from his hand and from the bank to accomplish the change. Each molecule must be named by its builder. Ordinarily, the displaced atoms are discarded to the bank. If, however, he who displaces them can explain how the substitution can be accomplished chemically, his opponent must take the displaced characters. Supposing the molecule on the table is methyl alcohol. A player removes two hydrogen atoms, one from the oxygen atom and one from the carbon, and connects the bonds left free. The result is formaldehyde. The player explains: "Formaldehyde can be obtained from methyl alcohol by passing a mixture of the alcohol vapor and air over a heated platinum spiral." The other player must add two hydrogen atoms to his characters. The first player disposes of none of his atoms, but adds to those of which his opponent must dispose.




TYPICAL CONSTRUCTIONS

The opponent of the player actually playing may call "Stop" if the latter executes a move which cannot be represented by any one reaction which the molecule on the table could undergo. The player executing the false move then loses a turn and the opponent gains one. A player wrongly stopped may add to his opponent's hand one atom from his own.




METHYLAMINE, THE TYPE OF A VERY IMPORTANT SERIES OF COMPOUNDS

A player may utilize his play in changing the positions of the various atoms to form an isomeric compound. His opponent must then choose an atom or group from the player's hand and add it to his own. If the player can explain how one form can be changed chemically to the other, his opponent must choose

two. If the player cannot explain, and the opponent can, no transfer takes place.

A textbook of organic chemistry should always be at hand to settle any questions that may arise concerning the correctness of any formula or reaction.

As the players' knowledge increases, the number of characters to be disposed of should be increased. The players may see chances to improve the game as they go along. They may formulate new rules and even new games. There is a chance for a similar game to embody inorganic displacement.

Chemical clubs will find the game useful for contests. The winner will probably be he who can plan for future plays and give his opponent atoms the latter will have trouble in disposing of.

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**Russia Finds Potassium Deposits in Urals.** Russia is no longer a customer for German potassium salts, source of fertilizers, and other widely used commercial chemicals.

In 1926 the Soviet government started investigations to see if Russia did not have any deposits of her own of these valuable materials, with the result that near Solikamsh in the Ural Mountains, potassium beds were found that the Soviets claim to be among the largest in the world.

A mine has been opened, workmen's quarters erected, and mining operations are said to have begun this summer. Some 5000 men are employed to handle the production which, it is estimated, will reach around 1,300,000 tons per year.—*Science Service*

**Insulin Proposed as Hunger Strike Breaker.** Insulin, which saves the lives of diabetic patients by ridding their blood of an overload of food in the form of sugar, is proposed by German prison physicians as a means of breaking the "hunger strikes" of obstreperous prisoners, according to an editorial note in the German scientific journal *Kosmos*. Injected into the blood stream of a healthy person, insulin acts in much the same manner as it does in a diabetic; that is, it reduces the amount of sugar. But if the amount of sugar is not excessive, it is reduced to the point of physiological starvation, and the "hunger striker" gets so sudden and violent an attack of the hunger he is striking for that he is unable to hold out, and asks for food.—*Science Service*

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Laboratories and discoveries are correlative terms. If you suppress laboratories, physical science will be stricken with barrenness and death, it will become mere powerless information instead of progress and futurity; give back its laboratories and life, fecundity and power will reappear. Ask that they be multiplied and completed. They are the temples of the future, of riches, and of comfort. There humanity grows greater, better, stronger. . . . In our century science is the soul of the prosperity of nations and the living source of all progress. Undoubtedly, the tiring daily discussions of politics seem to be our guide—empty appearances—what really leads us forward are a few scientific discoveries and their applications.—LOUIS PASTEUR

# A JANITOR'S LIFE

W. W. HEINTZ, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND

## CHARACTERS

*GRAPHITE, M.D.:* (Master of Dice)
*ANILINE:* His better half.

## STAGE

Has two entrances, table in middle with chair near table.

## PROPERTIES:

Two bills or stage money; light rolling pin made of cardboard rolled over light wooden discs; medicine bottle containing colored water; teaspoon; stick of wood to look like stick of dynamite; $KClO_3$ and red phosphorus; lumps of metallic Na or K; tongs for handling same; cake of ice with well in it; Pyrex beaker containing a little $KMnO_4$ and conc. $H_2SO_4$; small bottle of $C_2H_5OH$; $Hg(SCN)_2$ in paper tube to look like candle; pint whiskey bottle containing water; black goods tacked on frame with skeleton painted on it in luminous paint. (Luminous paint made by dissolving P in $CS_2$, mixing with olive oil and letting $CS_2$ evaporate. The luminosity lasts for only a few minutes while P is burning. Skeleton must be painted offstage during presentation of act.)

When curtain rises stage is empty. Rattling of door is heard.

*Graphite:* (Offstage) "Dawggone! Ah forgot muh key. O, Aniline—O, Aniline."

*Aniline:* (Also offstage) "Is dat you, yo' good-fo'-nuffin hunk of anthracite?"

*Graphite:* "Yeh, dat's me, honey lamb. Come on down an' let me in."

*Aniline:* (Enters in loud dressing gown, carrying rolling pin): "Don' yo' honey me. Wot you mean stayin' out all hours o' de night shootin' crap?"

*Graphite:* "Aw listen, sweetness. Yo' knows Ah was workin' tonight. Come on, open de do'."

*Aniline:* "Yeh, iffen yo' calls rollin' de gallopin' dominoes workin'."

*Graphite:* "Come on, sugar, open de do'; it's rainin' out heah."

*Aniline:* "Dat's all right; yo' all wet anyhow."

*Graphite:* "Come on, honey, open de do'. Ah got twenty bucks."

*Aniline:* "Huh?—Why didn' yo say dat in de fust place?" (Opens door and lets him in.) "Now gimme dem twenty bucks."

*Graphite:* (Reaches in pocket for money, grumbling, and hands it over): "Mah goodness, woman, dawggone it, you always—"

*Aniline:* "Now look heah, boy, de nex' time yo' all comes late like dis, Ah'm gonna raise such a bump on yo' haid dat when de ambulance comes to carry yo' off, yo'll *walk* and dey'll ride, dey'll ride de *bump*."

*Graphite:* "Wot's de mattah wif you, gal? Didn' Ah jus gib yo' twenny dollahs? Wot yo' want annyways?"

*Aniline:* "Yeh, but twenny dollahs won' pay yo' hospital bill nex' time. Who was yo' playin' wif tonight?"

*Graphite:* "Well, yo' see it uz dis way. Ah was ober in dat chemical buildin' sweepin' out when one nem boys by de name ob ————[1] come along un' say, 'Hey, Graphite, come on ober an git in de game.' An Ah say, 'No suh, Mr. ————, thank yo' kindly, suh, but ah done promise muh sweet wife neber to shoot crap no more.' But all dem boys come round' an' say dat iffen Ah don' play dey cain't hab no game. So Ah couldn' see all dem po' boys so dissamumpointed, so finally Ah says all right. An nen- -"

*Aniline:* "Yeh—Ah bet dey had to do a powerful lot of coaxin'."

*Graphite:* (Ignoring interruption) "Well, lessee, deh was dat ———— and dat boy by de name of ———— an' ———— an' ———— an' ————. Well, hit wa'nt long befoh muh little trained dice had 'em all broke so dey all looks roun' dat chemical buildin' for sumpin' else to put up. Now Ah show you what else Ah won."

*Aniline:* "Now wot yo' got, a bunch ob stuff to blow de house down lak yo' pret' near done las' time?"

*Graphite:* "No suh, Ah got heah some magic medicine, dat what Ah got. (Pulls out bottle of colored water.) Mr. ———— say dat one teaspoon full of dis heah an' you wont nebber grow old." (Goes to table, picks up teaspoon, starts to pour some out, spills some on floor and kicks pile of red phosphorus and $KClO_3$.)[2]

*Aniline:* "Yeh—Ah sees what he means now. Yo' won' hab no chanct to grow old."

*Graphite:* "Well, dat's all right, Ah got heah some real good ice preserver."

*Aniline:* "Ice preserver? What yo' mean ice preserver?"

*Graphite:* "Well, you see you puts hit on de ice and it stays friz fo' two yeahs."

*Aniline:* "Ah don' believe dat. Heah, lessee." (Drags out cake of ice. Graphite takes tongs from table and drops Na or K in well in ice.) "Ice preserver! Dat's de fust time Ah eber see ice burn. Go' long wiff you and yo' stuff."

[1] The blank spaces have been left to fill in local names.

[2] One must be very careful with the red phosphorus-potassium chlorate mixture. It should be mixed in very small quantities on the spot where it is to be used. By all means never touch the mixture with the hands and never carry it around in a bottle.

*Graphite:* "Now jes' wait a minute, deah, look heah—." (Brings out wooden stick.)

*Aniline:* "Boy, yo' bettah git outen heah wif dat. Dat look lak dynamite to me."

*Graphite:* (Throwing it up in the air and catching it): "Don' get scared, honey, dis ain' no dynamite, dis heah is real, harmless stuff. Dr. ———————— say dat dis is T.N.T."

*Aniline:* "What do T.N.T. stand for?"

*Graphite:* "Lessee, he say, try not to—try not to—Dawggone, Ah don' remember de las' part." (Absentmindedly tosses it through open door. There is a terrible explosion): "Ah remember now dat he say try not to drop it."

*Aniline:* "Hit suttenly is a good thing yo didn' drop it in heah."

*Graphite:* "Well, enny how, Ah got heah sompin what Dr. ———————— called a reducin' agent."

*Aniline:* "Reducin' agent, huh? Dat's fine. Ah'll take it down to de —(Sorority House) an' sell it."

*Graphite:* "Hit ain' dat kin'. Dis heah is a chemical reducin' agent. You jes pour a little out like dis an—" (pours alcohol on $KMnO_4$ + $H_2SO_4$). "Mah goodness, dat am hot stuff."

*Aniline:* "Go way fum heah, boy, you ain' done nuffin but show me a bunch of foolishments."

*Graphite:* "Now jes' hol' yo' hosses deh, honey, Ah got heah sompin what is real useful. Hits a ebber-burnin' candle. Yo' jes light it an' hit burns all de time." (Lights $Hg(SCN)_2$. Snakes come forth.)

*Aniline:* "Laws-a-mussey, now it's snakes. How much mo' trash did yo' bring home frum dat chemical building?"

*Graphite:* "Well—dat's all ceptin' fo' thutty dollahs."

*Aniline:* "Thutty dollahs?? Ah thought yo' said—"

*Graphite:* "Well-a-a yeh, Ah means—"

*Aniline:* "Yeh, Ah sees what yo' means. Up to yo' ol' tricks again. Now jes' fork ober dem ten dollahs." (Threatens him with rolling pin. He hands over money.) "Now you git outer heah."

*Graphite:* "But listen, sugar—"

*Aniline:* "Didn' Ah tell yo' de las' time dat de nex' time yo' held out on me Ah was gonna frow you out. Now git yo'se'f hence befo' Ah cracks you wif dis synthetic sleep seducer."

*Graphite:* "But hit's rainin' out deh—"

*Aniline:* "Git out!" (Pushes him out, slams door, and walks offstage mumbling to herself. When she has gone Graphite pokes head in door and then sneaks back onto stage.)

*Graphite:* "Hot Dawg! She forgot to lock de do'. Mah goodness, Ah

ain't nebber see nuffin like de temper what dat woman got. Dawggone, she's awful. Ah ain't got no rights aroun' dis place atall." (Feels hip pocket and brightens up.) "Well, by golly, heah's some good gin what Ah won tonight an' almos' forgot Ah had." (Pulls out bottle and takes a drink. Makes face as though it is very strong.) "Boy, dat stuff am good." (Takes another pull.) "Man, dat's real airplane liquor—two drinks o' dat an' it's hello St. Peter." (Sits in chair and after third drink begins to get sleepy.) "Man, dat certainly am potent stuff dat make me awful sleepy." (Falls asleep. Lights fade out. Ghost enters. Graphite groans and stirs as though in a nightmare.)

*Aniline:* (Offstage) "Stop all dat noise down dere and let a body sleep in peace." (Graphite continues to groan louder as ghost moves nearer.)

*Aniline:* "Iffen yo' don' stop dat racket dis instant Ah'm comin' down deh and gib yo' sompin' to groan about." (Graphite groans. Ghost leaves stage, lights come on. Aniline bustles in and strikes him with rolling pin.)

*Graphite:* (Letting out yell and jumping up.) "Eyow! de ghost!"

*Aniline:* (Chasing him off with rolling pin.) "Ghost, huh!—" Mebbe you'll think dis am a ghost!"

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**Graf Zeppelin Brings Cancer Culture to America.** The Graf Zeppelin on its speedy trip from Germany brought to the Cancer Research Laboratory of the University of Pennsylvania cultures of cancer cells of a special rat sarcoma type that would not have survived the long steamer voyage across the Atlantic.

"The cultures must be transplanted every few days and the Graf Zeppelin offered a quick method of transportation so that they may be transplanted on their arrival here," explained Dr. Ellice McDonald, director of the Cancer Research Laboratory of the University of Pennsylvania's Graduate School of Medicine, to whom the valuable cancer cultures were consigned. "It is almost impossible to carry the necessary laboratory apparatus to make these transplantations on board a steamship."

The growing cancer cells came from the Kaiser Wilhelm Institute für Biologie in Berlin through arrangements made by Dr. Raymond Parker of Dr. McDonald's staff and Prof. William Seifriz of the University of Pennsylvania. Dr. Parker has been studying this year with Prof. Albert Fischer of the Berlin institution.

Although not the same kind of cancer that affects human beings, the rat strain when safely established in its new American home will prove useful in the laboratory's study of mitosis or cell division. It is also expected that the cancer cultures will throw new light upon the possibility of the modification of the rate of growth or cell division by various chemicals and it is possible that such experiments may prove to be the starting point of new knowledge of the human disease. Human cancer, like the cancer of lower animals, such as the rat, is primarily a disease of cell division and the proposed studies upon the Graf Zeppelin culture are therefore fundamental.—*Science Service*

# HOW SMALL IS A MOLECULE?

R. E. ROSE, E. I. DU PONT DE NEMOURS & CO., INC., WILMINGTON, DELAWARE

If a human being could be reduced to the size of a molecule, and yet retain his faculties and senses, the world about him would look so different that it would seem an entirely new universe, not one single thing would remain unaltered. No one can actually become the size of a molecule but many of us can train ourselves to see molecules with our mind's eye. This is what we do when we become chemists and physicists.

How small is a molecule anyway? They are not all the same size, but even the largest is so much smaller than anything you can see that it is difficult to realize how minute they are. Of all the ways of defining the size of molecules, I think this one appeals to me most:

Suppose you draw a glass of water from the tap, and suppose that you are able in some miraculous manner to mark each molecule as a rancher brands his calves, and after having done this you empty the glass of water into the drain. Then you wait, and you wait long enough to allow that glass of water to mix uniformly with all the water in the world, in oceans, rivers, lakes, clouds, and animals and plants. You would have plenty of time to rest, because it would take a good many centuries. When the mixing is complete, if you draw a glass of water again and looking through pick out the molecules that you had marked you would find 2000 of them in the glass of water. You might think this just a chance, so you would draw another glass of water, again you would find 2000. Not believing this evidence you might gather rain water or go to the beach and take it from the ocean, or from a running brook. Always you would find 2000 of these original molecules in each glass of water, no matter where you get it from, whether in this country, or the arctic, or the tropics. In other words the concentration of marked molecules in all the waters of the world would become 2000 per glass, and all these molecules were actually in the original glass taken by you. If you could take the water out of your own body, you would find no less than 480,000 marked molecules in it, and if you could perform the same test on His Majesty, you would find the King of England had just as many.

This in itself sounds more amusing than valuable, but it is because the chemist has found out just such things about molecules that he has been able to make cotton linters and wood pulp into rayon, coal tar into dyestuffs, steam and coke into wood alcohol, carbolic acid into resins, the casein of milk into billiard balls, and do hundreds of other things that make it easier for us to live in comfort. Because the chemist thinks in terms of these minute molecules he is always thinking of turning one thing into another, not as the engineer does by putting it in a machine but by taking the component molecules and rearranging them.

## THE LIBRARY*

POPULAR SCIENCE MONTHLY, *July, 1929*

(*P. 17.*) "Doomed to Die—and They Live!" *Robert E. Martin.* A discussion of the cases of the five New Jersey women who were believed to have contracted radium poisoning while painting luminous watch dials. At the expiration of the year which physicians had estimated to be their reasonable expectation of life, their condition is found only "a little worse" than in June, 1928. It is now thought that the poison from which they suffer may be mesothorium rather than radium. If this theory proves correct there is an excellent chance that these unfortunates may live to a ripe old age—though no doubt in impaired health. The effects of radium and of mesothorium upon the human system are discussed. Other cases of radioactive poisoning are mentioned. (Illustrated.)

(*P. 21.*) "What John D. Rockefeller Has Done for Me." *Henry Morton Robinson.* An article based upon an interview with John D. Rockefeller and the annual reports of the Rockefeller Foundation, in which Mr. Robinson describes very interestingly some of the triumphs over disease which have been won with the aid of the five hundred and fifty million dollars which Mr. Rockefeller has contributed to scientific research and the promotion of public health. The development of type serums for pneumonia, the establishment of "Child Health Stations," the clean-up of the Southern hookworm belt, the battle against yellow fever, the excellent sanitation work which prevented the outbreak of epidemics after the last great Mississippi flood, the treatment of diabetes and anemia, the up-building of the University of Chicago, the establishment of the Peking Union Medical College, the relief work made possible by the Laura Spelman Rockefeller Memorial Fund—all are discussed in more or less detail.

(*P. 43.*) "What Goes into Your Car!" A series of pictures indicating many of the diverse materials which go into the building of an automobile, their sources, and the amounts which are used annually by the American automobile industry.

(*P. 59.*) "Novel Uses for Tantalum, Silvery-White Metal." Some of the physical and chemical properties of tantalum are described, and the uses to which it is already being put are enumerated.

(*P. 60.*) "Tests Vindicate Some Old 'Home Remedies.'" A brief note of some experiments conducted at Flower Hospital in New York City.

(*P. 61.*) "New Electric Lamp Bulbs Clean Themselves." Coarse tung-

* "The Library" will be brought up to date in the November number and will be kept so throughout the scholastic year.

sten powder is introduced into high-powered bulbs when they are made. When the bulbs blacken in use, they can be swept clean by shaking.

(*P. 66.*) "'Gassed' Eggs Kept Fresh by New Process." A note on the use of carbon dioxide for the preservation of eggs.

(*P. 111.*) "Home Workshop Chemistry." A few simple qualitative tests which may be used to identify some of the elements entering into alloy steels are described.

*August, 1929*

(*P. 31.*) "Has Our Earth a Glass Heart?" *John E. Lodge.* According to the theory of Dr. R. A. Daily, professor of geology at Harvard University, the core of the earth consists of molten glass at a temperature of 50,000°C. and under a pressure of 50,000,000 pounds to the square inch. Surrounding the core are strata of iron, basalt, and granite. Other geologists, notably Dr. R. R. Cummings of Indiana, disagree with Dr. Daily's theory. (Diagram.)

(*P. 32.*) "Reese—A Man Who Always Does the Impossible." *Frank Parker Stockbridge.* A good article saddled with a regrettably sensational title. In this interview we learn how American chemists, in a race with time, discovered how to prepare diphenylamine, a stabilizer for smokeless powder, which had hitherto been manufactured by secret processes in Germany. Processes for the manufacture of toluene, another war-time necessity, were also worked out under Dr. Reese's direction. An outgrowth of this latter research was the production of xylol and the development of a new high explosive—trinitroxylol (T. N. X.).

A brief sketch of Dr. Reese's schooling and earlier experience up to the founding of the du Pont research laboratories which he now directs is included. There is a somewhat fuller account of later problems which Dr. Reese has helped to solve. These include: nitrogen fixation, rayon production from wood pulp, and the development of pyroxylin lacquers. (Portrait.)

(*P. 50.*) "A Poor Shot Led to Tinless Tin Cans." A helper accidentally tossed a box of chemicals into a 100-pound pot of molten aluminum. The result was a new aluminum alloy which, according to its discoverers, can now be plated upon iron. The new plate may rival the tin-coated iron which is now almost universally employed in the manufacture of "tin" cans.

(*P. 50.*) "Facts about Poison Gas in Cleveland Tragedy." Experts who investigated the Cleveland Clinic Foundation disaster estimated that the 75,000 pieces of burning film generated about 1,000,000 cubic feet of gas—enough to kill 4,000,000 people. About thirty per cent of the deadly gas was "nitrogen oxide;"[1] another thirty per cent was car-

[1] Undoubtedly $NO_2$ or $N_2O_4$ is meant here.

bon monoxide, and the remaining forty per cent was largely harmless. Concentrations of one part in one hundred of either CO or $NO_2$ are deadly.

(*P. 57.*) "Deadly Chemicals Purify City Drinking Water." A note on the chlorination of city water supplies. (Illustrated.)

(*P. 61.*) "Mountains of Waste Paper Salvaged by Machinery." A note on the conversion of waste paper into wrapping paper. (Illustrated.)

(*P. 63.*) "Oxygen Piped in Hospital." A new invention devised to regulate the flow of the gas makes it possible to pipe a constant supply of oxygen to rooms in a hospital for administration in case of emergency.

(*P. 63.*) "New Rustless Steel Cuts Glass Like a Diamond." A "nitrated" steel of exceptional hardness, which it retains even at red heat.

(*P. 64.*) "Curious Mineral Squirms and Sweats under Heat." A large deposit of vermiculite[2] has been found near Libby, Montana, by a prospector who was searching through an old tunnel. He noticed flakes of coarse, mica-like material writhe and swell and give off water when touched by the flame of his candle. Although no commercial use has been found for vermiculite, its properties suggest that it might be convertible into a valuable insulating material, for when expanded it is very light and has low heat conductivity.

(*P. 107.*) "Home Chemistry Workshop." Directions for the preparation of a cobalt chloride humidity indicator and a water-color comparison scale to accompany same.

### SCIENTIFIC AMERICAN, *July, 1929*

(*P. 12.*) "Health and Happiness." *Editorial.* Dr. Ales Hrdlicka, after a five-year investigation of physical and physiological characteristics of members of the National Academy of Sciences, announces that scientists are of superior physique, strength, health, and longevity, as compared with the average American. The editorial writer discusses this announcement and quotes Bertrand Russell as follows: "Men of science, who have less difficulty than others in finding an outlet for their creativeness, are the happiest of intelligent men in the modern world, since their creative ability affords full satisfaction to mind and spirit as well as to the instinct of creation. In them a beginning is to be seen of the new way of life which is to be sought; in their happiness we may perhaps find the germ of a future happiness for all mankind."

(*P. 12.*) "What Science Signifies." *Editorial.* A discussion of the far-reaching and unpredictable practical applications which may arise out of discoveries in pure science. A number of historical instances are mentioned.

[2] Vermiculite is the name given to any one of a number of micaceous earths (such as kerrite and maconite), which are hydrous silicates.

(*P. 18.*) "The Marvelous Machinery of Muscle." *Donald A. Laird.* A non-technical explanation of the physical and chemical phenomena involved in muscular action. Factors giving rise to fatigue as well as essentials to fatigue recovery are discussed. Some effects of diet upon muscular activity and efficiency are briefly described.

(*P. 28.*) "Estimating the Age of Writing." *C. Ainsworth Mitchell.* The author, who is secretary to the Society of Public Analysts, tells of some of the chemical changes which take place in writing inks over a period of time. He shows how a knowledge of these facts can be applied to the solution of legal problems and cites a number of illustrative cases.

(*P. 32.*) "The Ultra-Violet from the Sun." *Richard Ruedy.* The author accounts for the variation in intensity of the ultra-violet in sunlight which reaches the earth on the basis of an ozone layer in the upper atmosphere.

(*P. 77.*) "Chemistry in Industry." Under this general title are grouped the following items: Case Hardening Steel by Nitrogen Treatment; Germany's Chemical Industry Expands; Proposes Power from Polar Cold; Mysterious Superiority of Leviathan's Steel Plates a Myth; Columbium May Come Out of the Museum; Sunflower Seeds Supply Russia with Potash; Titanium Pigments Invade the Paint Field; Corrosion-Resistant Metals Not Immune to Electrolytic Corrosion; New Paving Uses Steel Framework; Furfural Becomes a Staple Commodity; Sulfur Dioxide Health Hazard Exaggerated; New Arc Light Carbons; Grading Cottonseed by Analysis; Expansion Effects in Concrete Explained; Metaldehyde Developed as Fuel in Germany; Soap Improves Concrete; Nitrogen Gas Cuts a Freight Bill; Imitation Ice for Skating; Synthetic Building Stone Predicted; First Aid for Chemical Burns.

*August, 1929*

(*P. 148.*) "Foiling the Burglar—II." *A. A. Hopkins.* A discussion of the construction of safes and vaults with some consideration of the steels and other materials employed to delay the burglar in his operations. (The first article of the series deals with locks and keys.)

(*P. 160.*) "Vast Supply of Anthracite Chokes Rivers." It is estimated that enough hard coal to supply the demand of the United States for ten years lies in banks and bars which choke the valleys of three rivers in Pennsylvania. This coal has been washed from old culm piles and from breakers. Much of this coal is being reclaimed and is used by plants which are equipped to burn powdered fuel.

(*P. 167.*) "The Danger from X-Ray Films." A discussion of the gaseous combustion products of nitrocellulose films and their physiological effects. The toxic gases liberated in the recent Cleveland disaster were probably $NO_2$ or $N_2O_4$ or a mixture of both, with the possible

admixture of some CO. These fumes could not have been bromine, as the newspapers at first reported.

(*P. 170.*) "Chemistry in Industry" includes the following titles: What Is Petroleum? Sulfur in Air Attacks Drying "Wash;" Chemical Belt Dressing Eliminates Statics; Chemistry Contributes to Better Bricks; Unique Instruments Test Properties of Paint; "Stickum" for Stamps; Scientific Dish Washing; Peroxide Also Bleaches Cereals; New Oil for Old.

SCIENCE AND INVENTION, *July, 1929*

(*P. 200.*) "Is a College Education Worth While?" A series of brief discussions giving the opinions of H. T. Parson, President of F. W. Woolworth Co.; Walter P. Chrysler, President of Chrysler Motors; and Prof. F. E. Austin, formerly of the Thayer School of Engineering and Norwich University.

(*P. 231.*) "Adsorption." *Raymond B. Wailes.* Nine simple experiments illustrating some of the qualitative aspects of adsorption. (Photographically illustrated.)

(*P. 246.*) "Wrinkles, Recipes, and Formulas." "Optician's Rouge." Optician's rouge can be made by heating copperas to redness in a crucible for several minutes. "Grinding Stoppers." The coarse grade of valve grinding compound sold by garages can be used for seating glass stoppers. "Tests for Tooth Pastes." Tests for chlorates, carbonates, and soaps are suggested. "Suction Filler." A device for filling pipets without applying the mouth.

*August, 1929*

(*P. 307.*) "X-Ray Films Cause Disaster." *H. Winfield Secor.* A discussion of the decomposition products arising from the combustion of pyroxylin films in confined spaces and suggestions for the prevention of disasters similar to that which recently occurred in Cleveland. (Illustrated.)

(*P. 318.*) "Self-Cleaning Lamp." Before-and-after photographs of the new General Electric Co. lamp which can be cleaned, after the inside walls have been blackened, by shaking. The cleaning agent is a tablespoonful of coarse tungsten powder which is introduced into the lamp before sealing.

(*P. 320.*) "Is a College Education Worth While?" The views of Justice John Ford of the Supreme Court of New York; Frances Rockefeller King, President of the Frances Rockefeller King, Inc., Bureau; and Major-General Amos A. Fries, U. S. Army, Retired.

(*P. 323.*) "Space, Time, and Relativity." *Donald H. Menzel.* An elementary presentation of the postulates of the general theory of relativity, some of their practical implications, and the outcomes of experiments which have been devised to test them.

(*P. 330.*) "Experiments with Acetic Acid." *Ernest Bade.* Directions for the preparation, from acetic acid, of acetyl chloride, acetic anhydride, cellulose acetate, ethyl acetate, and for further experiments with some of these products are given. (Illustrated.)

(*P. 342.*) "Wrinkles, Recipes and Formulas." "A Silver Fluid." A fluid for silvering brass and copper articles can be made by taking 1 oz. of precipitated silver (*sic*) and adding to it $^1/_2$ oz. of potassium cyanate and $^1/_4$ oz. of sodium thiosulfate. Add 1 qt. water and a little whiting. Shake before using. Apply with soft rag. "Blue Ink." Prussian blue, gum arabic, boric acid, and water (proportions not definite). "Microscope Cement for Opaque Objects." A good transparent cement can be made by taking 2 parts isinglass, 1 part gum arabic, and covering with proof spirits. Place in loosely stoppered flask and heat in water-bath until solution is effected. Filter. "Fireproof Match." Match sticks can be fire-proofed by dipping to within $^1/_2$ inch of head in water-glass solution. Dry.

POPULAR MECHANICS, *July, 1929*

(*P. 6.*) "Old Mill Ponds to Yield Millions of Dollars." Improved methods of metallurgy are now profitably extracting millions of dollars in gold and silver from the tailings which were discarded by mills in the earlier days.

(*P. 33.*) "Fruits Ripened by Gas to Aid Growers." Equipment, said to cost $30 or less, is now available to fruit growers for artificially ripening fruits and some vegetables with ethylene. (Illustrations.)

(*P. 62.*) "Chemical Has Scent of Musk Like Natural Product." Artificial musks, that sell as high as $275 per ounce, are being manufactured in the chemists' laboratories. . . . The success of the chemist in this direction may prevent the extinction of the musk deer which are now being killed at the rate of 50,000 to 100,000 a year in the mountains of Tibet and western China.

(*P. 80.*) "Rich Deposit of Rare Ore Found in Nevada." What is declared to be the only known commercial deposit of brucite, a rare mineral that can be used where other magnesium minerals are now employed, has been discovered and opened to some extent near Luning, Nevada. One and one-half tons of brucite are equivalent to more than two tons of magnesite ore and comparison with other magnesium ores is even more favorable to brucite. (Brucite is essentially magnesium hydroxide; magnesite is magnesium carbonate.)

(*P. 88.*) "Freezer Makes 'Dry Ice' Disks to Preserve Ice Cream." Disks of solid $CO_2$ can now be made as occasion arises at the soda fountain counter, to keep ice cream from melting while it is being carried home in paper or other containers. The freezer is handsome in appear-

ance and may be installed on the counter, while the gas cylinder is hidden in the basement or other convenient chamber. (Illustration.)

*August, 1929*

(*P. 203.*) "Gold and Quicksilver Found under Old Mill Sites." Gold, mercury, and silver are being recovered from abandoned mill sites where thirty years ago amalgamation was the only process used to recover gold.

(*P. 225.*) " 'Chemist' Guards Town's Water Supply." A Swiss inventor has introduced an automatic device which tests the purity of water and controls the chlorinating process.

(*P. 247.*) "Tomatoes Guard Flowers." Tomato plants can be used as very sensitive detectors for indicating the presence of toxic gases before they reach sufficient concentrations to injure other plants, just as canaries have sometimes been used in mines to guard workmen. The tomato plant is much the more sensitive detector of the two.

(*P. 271.*) "Safer X-Ray Films to Reduce Explosion Hazards."

(*P. 285.*) "Washes for Citrus Fruits Reduce Decay Losses." The Bureau of Plant Industry has been testing various washes with a view to developing practical methods for the elimination of $100,000 or more annual loss to fruit shippers through decay. Treatment with sodium bicarbonate is said to have produced excellent results.

(*P. 290.*) "New Metal Like Platinum Found in Granite." Resembling platinum in appearance and in some of its qualities, columbium can be produced for one-tenth the cost. Researches are now seeking to determine what uses can be made of the newly available metal.

(*P. 291.*) "Oil from Florida Trees." The tung oil or China-wood oil industry, established in north central Florida as an experiment, is now becoming a thriving commercial enterprise. Through the use of modern methods of propagation and oil extraction, a highly superior oil can be produced more economically than can the dirty, adulterated product now imported from China. The goal of the American tung oil industry is the ultimate establishment of 300,000 acres of bearing groves. By-products are valuable as fertilizers. (Illustrated.)

(*P. 321.*) "Homemade Crystalline Lacquer." An attractive crystalline lacquer for instruments can be made by dissolving naphthalene crystals in any ordinary brushing lacquer of standard make.

(*P. 347.*) "Cork Gage for Laboratory Workers." A handy cork gage can be made by nailing corks of different sizes to a board near the bins in which the corks are kept. (Illustrated.)

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He that will not apply new remedies must expect new evils; for time is the greatest innovator; and if course of time alters things to the worse and wisdom and counsel shall not alter them to the better, what shall be the end?—SIR FRANCIS BACON, *1612.*

## THE A. C. S. PRIZE ESSAY CONTEST

The generous gifts of Mr. and Mrs. Francis P. Garvan, which have made possible for some six years past the annual prize-essay contests conducted by the American Chemical Society, have again been renewed. The Committee on Prize Essays has met and agreed upon the regulations which will govern the contest for the coming year. Full information will soon be available for distribution to prospective contestants and their instructors.

In but one important particular do the rules of the contest differ from those of last year, and that particular relates only to the college essays. In the high-school and normal-school classes the six general topics used hitherto are again assigned for discussion. In the college class, the general topics will not be employed; instead, the contestants are given the choice of thirty specific topics. The specific topics, grouped under the appropriate general topics, are as follows:

### The Relation of Chemistry to the Development of an Industry or a Resource of the United States

1. What Chemistry Has Accomplished in the Meat-Packing Industry
2. The Contributions of Chemistry to Aerial Transportation
3. The Rôle of Chemistry in the Industrial Development of My Town (or State)
4. Chemistry the Salvager
5. The Relation of Chemistry to the Refining of Oil

### The Relation of Chemistry to Health and Disease

1. Chemical Control of Foods and Beverages
2. The Chemistry of Garbage Disposal
3. Chemistry and Public Health
4. What Chemistry Has Taught Us about the Relation of Food to Health
5. Synthetic Medicines

### The Relation of Chemistry to Agriculture or to Forestry

1. Forest Conservation by Utilization of Timber and Lumber Wastes
2. The Warfare of Chemistry against the Insect Foes of Agriculture
3. Utilization of Agricultural Wastes
4. The Chemistry of Crop Rotation
5. Fertilizers—One of the Vital Contributions of Chemistry to Agriculture

### The Relation of Chemistry to National Defense

1. Is the Use of Gas in Warfare Justifiable?
2. Chemical Industry as an Insurance of National Safety
3. Chemical Warfare; Offensive and Defensive
4. Chemistry in the Prevention, Detection, and Prosecution of Crime
5. The Relation of Chemistry to Air Defense

THE RELATION OF CHEMISTRY TO THE ENRICHMENT OF LIFE

1. Chemistry as an Aid to Cultural Enjoyment
2. Chemistry and the Artist
3. The Rôle of Chemistry in Visual Instruction and Entertainment
4. Chemistry in the Preservation of Art Treasures
5. How Chemistry Has Helped Make Good Music Available to the Masses

THE RELATION OF CHEMISTRY TO THE HOME

1. The Relation of Chemistry to Cleanliness and Sanitation in the Home
2. Chemistry and Esthetics in the Home
3. Chemistry and Cooking
4. Chemistry and Household Conveniences
5. Chemistry as a Factor in the Economics of the Home

Further details concerning the rules of the contest will appear in the next number of the JOURNAL. All inquiries and requests for bibliographies should be addressed to: Paul Smith, 654 Madison Avenue, New York City.

Until the new bibliographies become available, we refer those who would like to begin work immediately to the reading list published in the September, 1928, JOURNAL, pp. 1172–7.

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**Qualities Used for Grading Students.** Students are graded on moral and civic qualities in Flathead County (Mont.) High School. Each student is graded by all his teachers in sportsmanship, school spirit, honesty and trustworthiness, openmindedness, consideration for the rights and opinions of others, coöperation, initiative, leadership, industry, application, courtesy, manners, and mental and moral cleanliness. The records are permanently filed.

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Science alone can give us a true conception of ourselves and our relation to the mysteries of existence. Only the sincere man of science—and by this title we do not mean the mere calculator of distances, or analyzer of compounds, or labeler of species; but him who through lower seeks higher and eventually the highest—only the genuine man of science, we say, can truly know how utterly beyond not only human knowledge but human conception is the universal power of which nature, and life, and thought are manifestations.—HERBERT SPENCER

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**Simplification of Science.** The sciences, says Paul Valery of the French Academy, instead of being further complicated, are becoming simplified through the discovery of central principles; physics is merging into chemistry and chemistry into biology; the artists are studying the conclusions of physicists, mathematicians, psychologists; and it is not impossible that a new Leonardo will arise to include the whole field of intellectual activity in his scope—leaving his theories to guide the methods of every science, and his works as a model for every art.—*Business Chemistry*

# Correspondence

## STEALING MARKS

I note on page 1516 of the September number of the JOURNAL OF CHEMICAL EDUCATION a clipping from the *High-School Teacher* quoting the *Kadelphian Review* as authority for the statement that Washington & Lee has abandoned the "honor system."

I want to assure you that the statement is absolutely false and that there has never been a thought of abandoning it. Considering that our students come from prep schools throughout the country, it is not remarkable that there are occasional cases to be dealt with by the Student Executive Committee, but most of the freshmen take to it like ducks to water. I think its working is about 99.44% pure!

The mere intimation that it has been abandoned here is so serious that I hope you can see your way clear to correct the statement in an early issue of the JOURNAL.

Yours very cordially,

JAS. LEWIS HOWE

DEPT. OF CHEMISTRY
WASHINGTON AND LEE UNIVERSITY
LEXINGTON, KENTUCKY

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**Chemistry Aids in Biological Studies.** The chemist has been of much assistance to the biologist in the past, and can be of even greater assistance in the future if the two sciences are brought into closer coöperation, Prof. George Barger of Cambridge University told his colleagues at the recent meeting of the British Association for the Advancement of Science at Cape Town, South Africa.

In the past, the resources of chemistry have been applied largely first to questions of the construction of organic substances and then, as more delicate methods of analysis have been evolved, to an attempt to study the mechanism of the living organism at work. In the first field success has been so great that vast industries are now founded on the applications of organic chemistry; in the second, the battle is still going forward.

Prof. Barger suggested that if botanists would become chemists they might find some problems in supposedly non-chemical parts of botany easier of solution. Up to the present, no one has attempted to determine the species of a difficult flower, but some specialists in the lowly lichens have found chemical methods handy. Bacteriologists also regularly find the chemistry of their microscopic organisms useful in determining identity. But methods for determining what a higher plant is by putting a bit of it into a test tube have still to be worked out.—*Science Service*

# Chemical Digest

## THE NEW INTRODUCTORY CHEMISTRY. PART I

A. T. Bawden, Shanghai Baptist College, Shanghai, China

The author has spent most of his time during the last six years in the development of an introductory chemistry course designed to satisfy the needs for non-technical students, and to furnish a proper background for technical students. The purpose of this article is to set forth the prinples which guided the author in working out this course.

### The Need for a New Type of Introductory Chemistry

James Harvey Robinson, in his stimulating book, "The Humanizing of Knowledge," has pointed out the necessity of humanizing knowledge if continued progress is to be made in the pursuit of knowledge. He has pointed out many of the difficulties in the way of this. Among these difficulties he mentions that of specialization, which is indeed a great problem in this age of specialists, concerning which he says in part:

> In the enterprise of humanizing knowledge, it is necessary first to recognize that specialization, so essential in research, is putting us on the wrong track in education. This has been suspected for some time.

In addition to the evils resulting from giving technical courses to non-technical students, Stephen Rich[1] lists some of the misconceptions of chemistry teachers as follows:

> 1. The belief that the chief actual or desirable outcome of chemical instruction is a "general training," a "discipline," a set of "general abilities," such as those labeled "to observe accurately," "to draw correct or reasonable conclusions," and the like. This doctrine is neither more nor less than a belated survival from pre-scientific psychology.
> 2. Covering a logical outline as a whole.
> 3. We are teaching the subject rather than the pupil.
> 4. That the first-year course in chemistry, whether taught in high school or taught in college, is only an introductory course, to be followed by other specialized courses.
> 5. That of thinking that chemistry is essentially a mass of information.
>
> The remedy which I propose for this situation is that the high-school chemistry course should be revised with the basal idea that those who take it are not going to study more chemistry, that they are not going to be chemists, and that their specific needs should be met. It is certain that the existing courses do not meet their needs.

[1] "Some Misconceptions of Chemical Education," This Journal, **2**, 142–5 (Feb., 1925).

Leonard Koos,[2] has shown that high-school and college chemistry courses resemble each other much more than they differ, and that the average college general chemistry course is largely a repetition of the usual high-school course.

S. R. Powers,[3] in an abstract of this article, says:

This study affords a factual basis for the statement that the high-school course in chemistry is but an abbreviated college course.

Stubbs[4] says:

1. High-school chemistry is still too much under the influence of the college and the benefits of such dominance are outweighed by the defects.
2. Present-day methods often aim to turn out chemists rather than intelligent citizens who are appreciative of chemistry.

He believes that the second objection may be overcome by selecting subject matter as follows:

1. Only matter socially worthwhile.
2. Only topics that follow native interests of boy or girl.
3. Only matter which lends itself to the following general aims: appreciation of commonplace environment, new knowledge applicable to various fields of human endeavor, and training in scientific thinking.

Powers[5] says:

Each of the tests of subject matter points to the conclusion that a large proportion of the content of high-school chemistry is of little or no value for many who study it.

Mr. Morgan[5] says:

If it is worthwhile to seek to place the responsibility for the situation found to exist in the teaching of high-school chemistry, we may ask—who trains the teachers? Who writes the textbooks used? Who compiled "The Standard Minimum High-School Course in Chemistry?" Who makes up the college entrance Examination Board tests? The answers to all of these questions are much the same. College teachers cannot escape a large portion of responsibility for the content of high-school courses in chemistry.

Since high-school chemistry courses are largely abbreviated college chemistry courses, the inference is strongly suggested that the content of many of our college chemistry courses is of little or no value to many who study them.

Charles Stone[6] says that the time has come "when the rights of the ninety per cent must be more fully realized."

[2] "Overlapping in High School and College," *J. Educ. Res.*, **11**, 322–36 (1925).

[3] THIS JOURNAL, **2**, 798–802 (Sept., 1925).

[4] "The Place and Problem of Chemistry in the High-School Curriculum," *Sch. Sci. Math*, **27**, 741–8 (1927).

[5] Symposium: "What Are Our Objectives in Teaching Chemistry?" THIS JOURNAL, **2**, 971–5 (Nov., 1925).

[6] "The High-School Chemistry Course versus the College Requirement," *Ibid.*, 1, 55–8 (Jan., 1925).

What are the rights of the ninety per cent of those students who take high-school chemistry and the large number of college students who take general chemistry as their only course in chemistry?

H. R. Smith[7] gives the objectives in teaching chemistry as follows:

1. To bring about as soon as possible the pupil's appreciation of training in scientific method and chemical knowledge.
2. To teach pupils the understanding and use of the scientific method of solving problems.
3. The correlation of facts to build a unit of knowledge (a principle or law).
4. The application of principles and laws to new situations in the solving of daily problems (vocational and leisure time education).
5. Coöperation in community groups to promote human welfare.
6. The development of moral law and religious attitude in daily life.

J. O. Frank[8] summarizes the objectives of high-school chemistry as follows:

. . . getting pupils to comprehend ideas, to think chemistry in terms of the systematic organization of the subject matter, and the fusion of all the facts, laws, principles, and concepts, together with their innumerable applications into a complete subject, will be the main job of the teacher. . . . A good course in chemistry should leave the pupil with a strong desire to go further with the subject.

Arthur H. Bothe[9] has shown that:

The practical or useful side of high-school chemistry is not sufficiently stressed in our high-school texts, and that the average high-school chemistry textbook now in use is not adapted to the capacities, interests, and needs of the secondary school pupil.

J. E. Bell[10] says:

That the public is grossly ignorant of chemistry and the value of chemical knowledge in the solution of public problems needs no argument before a body of this kind. This ignorance exists among educated people, among men of affairs, and among most of those who at the present time comprise our leaders in society and mold public opinion. It is important, therefore, that we take steps to dispel this ignorance. We should see to it that it does not exist among our future leaders, that we plan this course with these future leading citizens definitely in mind. *They are more to be considered than the ones who are to specialize in chemistry.* Any false notions or any deficiencies in the preparation of the specialist, there will be ample opportunity to correct; but the impression the one-course man carries away is likely to be retained for life. Will he go with the feeling, even though unexpressed, "I certainly did a lot of cramming in that course, and I'm glad it's over with. What does it all mean anyhow?" Or can he be made to feel, "An interesting subject. It gives me a clue to the explanation of a lot of things. I'd like to inquire further into some of them."

[7] THIS JOURNAL, **2**, 585–7 (July, 1925).

[8] "The Objectives of High-School Chemistry," *Ibid.*, **2**, 53–7 (Jan., 1925).

[9] "An Analysis of High-School Texts in Chemistry," *Ibid.*, **2**, 785–91 (Sept., 1925).

[10] Symposium: "What Are Our Objectives in Teaching Chemistry?" *Ibid.*, **2**, 977 (Nov., 1925).

It is evident, then, that the present courses in chemistry for non-technical students in high schools and colleges are failing. Many leading educators are gradually arriving at the conclusion that specialization is the business of the graduate college, and that it should begin about the junior year in college. High-school and junior college courses are gradually developing into survey courses whose purpose is

> To enable our youth to realize what it means to live in society, to appreciate how people have lived, and to understand the condition essential to living together well, to the end that our youth may develop such abilities, inclinations, and ideals as may qualify them to take an intelligent and effective part in an evolving society.[11]

It will be of interest to see what some of our leaders who are working on this problem suggest as a solution.

Walter Jackson[12] says:

> Either the high-school course, the college course, or both, must change. I believe we will agree that it is the duty of the high school to do most of the reorganizing, with the help and sympathy of the colleges. Certainly we will agree that our high-school course has been merely a vest-pocket edition of the college course. If the college was the first on the ground, and it certainly was in chemistry, then it is largely up to the high-school man to find his place....
>
> So far, we have been largely destructive. Let us see if we can give some constructive suggestions. In the first place, we feel that the high-school chemistry course should be an inclusive unit within itself and not be dependent upon being capped off at some future period with a college course. The course should be so arranged that the pupil will have been given valuable training, viewpoints, and information when he finishes, whether he ever goes to college or not. Furthermore, the course should be so valuable that the pupil who does go to college will have had in high school a course that will never be repeated in college, and he can feel that he has something that no college course will ever give him, just as the college course offers something that the high school should never try to give....
>
> I propose that the high-school chemistry course shall be an intensive appreciation course. Don't pass judgment too quickly on a novel idea. Much will have to be learned in order to appreciate. If all of our high-school chemistry students will leave school with some idea of the magnitude of the service of chemistry to our nation, then I feel that we will prosper as we have never prospered before. When the high-school pupils—the masses—realize that it is possible for the chemist to take a waste material like coal tar, and a disagreeable one at that, and produce from it all the hues of the flowers that made the coal, along with their original fragrance, the healing properties of the roots and herbs, the flavors sought the world over by mankind, the sweetness that makes sugar taste like a washed-out syrup, the power that will actually do deeds that would make Hercules bow down as a humble servant—then, my friends, we have pupils who can, to some extent, appreciate the word chemistry. They will never know all about how all these things are done—no, never; but they will have a faith and belief that will cause them all their lives to give unto the chemist the things that belong to chemistry.

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[11] Preliminary report of the Joint Commission on the "Purpose of Social Solution Studies in Our Schools."

[12] "What Sort of Chemistry Should Be Taught in the High School?" THIS JOURNAL, 4, 58–65 (Jan., 1927).

How can this appreciation be brought about? I would suggest as wide reading as possible on each topic that is brought up for class discussion. As many contacts as the pupil can make with his everyday surroundings and readings will impress and reimpress him with the importance and unity of this subject. With entertaining books like "Creative Chemistry," "Chemistry in Industry," and others that may easily be had, with magazines each week and month, publishing articles that are both instructive and entertaining, with hundreds of industrial concerns publishing and giving away material that is useful in this way, with all of this, and a little guidance from the teacher, it should be easy enough for the pupil to understand and appreciate some of the workings of chemistry.

When a pupil finds that most industries are chemically controlled; when he finds out that the chemical industries are housed in huge factories and not in test tubes and that they turn out their products by the hundreds of tons; and when he finds that all of this goes into our everyday life—then will the pupil *appreciate* the fact that the chemist is not a pill pounder, but a creator. When this appreciation is built up among the masses that never go to college, then a new day will dawn for the chemist who does finish his education, for the good of each group, the whole nation, and posterity to come.

This appreciation course will be of definite value to the individual. He will have one more contact with the world through which a more abundant life can flow to himself. He can find recreation in reading intelligently a wider variety of material. His mind has been broadened. He may not know all the details—but he does know that they exist.

Dr. Edwin Slosson has said:

Science teachers in the secondary schools occupy a strategic position for influencing the thought of the nation. They give all the instruction that most of the people ever get and they have the first chance at those who go on to the university. Upon such teachers, therefore, rests the responsibility of presenting science in the beginning in its integral and humanistic aspects. I venture to say that such a presentation gives the best foundation for future specialization and abstraction.

By "secondary schools," Dr. Slosson would undoubtedly agree that he meant the junior college as well as the high school.

W. D. Bancroft[13] has expressed the need for a new type of course as follows:

The universities have two functions in the teaching of the sciences. They should teach a science as a professional study and as a cultural study. In the case of chemistry, the universities teach chemistry fairly well as a professional subject for the chemists, the medical men, the biologists, the engineers, etc. So far as I know, there is no university which now teaches chemistry as a cultural study—as a part of a general education. In almost all places the unfortunate student who would like to learn something about chemistry is forced to take the introductory or freshman course in chemistry This is, and must necessarily be, entirely unsatisfactory. Freshman chemistry is avowedly and properly a professional course. It leads up to qualitative and quantitative analysis, to organic chemistry, to physical chemistry, and to other advanced courses in chemistry and medicine.

The course in general chemistry does not cover enough ground to be of real value to the student seeking a general education and it goes into far too much detail for him. The better it is as a professional course, the worse it is as a cultural course....

[13] "Pandemic Chemistry," THIS JOURNAL, **3**, 396–8 (Apr., 1926).

Since chemistry is the fundamental science, the one which we are always encountering in some form and in some place, it is particularly desirable that everybody should have some knowledge of chemistry; and yet the teaching chemists do nothing to make this possible. We have nobody but ourselves to thank for it. The chemists complain, and very properly, that the business men and the bankers are deplorably ignorant of chemistry; but the chemists provide no way for the prospective business man to get even the rudimentary knowledge of chemistry as a whole.

What we need as a cultural course in chemistry is a course which will cover all the ground in chemistry given in the universities without going into too much detail. This means a series of popular lectures covering the whole field of chemistry as well as it can be done in the time. I urge the giving of a course of this sort, primarily for the benefit of the man who is expecting not to go on in chemistry. This course will be called pandemic chemistry (pandemic—of, or pertaining to, all the people). Almost all chemists are agreed that such a course should be given, but the difficulty is to decide just what ground it should cover.

The proposed course in pandemic chemistry is interesting from another viewpoint. Since most of the students in the public schools do not go to college, it would be much better for them to have a course in pandemic chemistry rather than the introductory course which they now have. Before that can come to pass we shall have to have a textbook for the students to study; we shall have to have teachers competent to give instruction in the subject; and we shall have to educate the colleges to the point of accepting this work for college entrance. This will take much time, although a textbook must be written at once for the benefit of the college student. It is merely a question of time, however, when this reform will go through the schools and in the colleges. When that time comes, people will wonder why it was not done before.

Neil E. Gordon[14] also expresses the need for a course of this kind in the following words:

Many teachers of chemistry have too long made of their beloved science a sort of sacred cow. To vary the metaphor, we have constructed a Procrustean couch which fits few students, but which every student must be made to fit. We have taught a subject rather than students.

Perhaps that is a harsh way of putting it. Courses in chemistry were first evolved for the benefit of those who desired to devote their lives to science, or for others who possessed what we may call the truly scholarly turn of mind. Chemistry has been taught, in the main, by men who belonged to one of those two classes. It is only natural that the original tradition should have persisted.

We are now faced by the fact, however, that many of our students have not the scholarly turn of mind and that many of them are preparing for work to which chemistry has no direct relation. We are called upon to adopt a new point of departure—to ask ourselves what chemistry can be made interesting and useful to the students with whom we have to deal rather than how a preconstructed system can be hammered into all comers. . . .

The average chemistry course of today does not sufficiently prepare the student to understand the everyday world about him. Certainly, it does not give him the knowledge necessary to any intelligent interest in the further development of science. Nearly all of our textbooks include "practical applications," but these are thrown in as afterthoughts—at any rate, as entirely secondary to the serious matters of formal chemistry. And there is too great a hiatus between the point where we drop the student and the

[14] THIS JOURNAL, **4**, 941–4 (Aug., 1927).

point where new developments are taking place. The first of those defects calls for a re-arrangement of subject matter and a shifting of emphasis; the second calls for a more extended and hence, to some extent, more superficial or a more selective treatment, or both.

James F. Norris[15] says:

In my judgment, the selection of the content of the course in chemistry to be followed by the college student as a part of a liberal education should not be influenced by a desire to plan the work as a preparation for the subsequent education of the specialist in the science. This error has been made frequently.

## The Principles Which Have Guided Us in the Selection of the Content of a Course in the New Type of Introductory Chemistry

*1. Chemistry must be presented from the viewpoint of service.*

To quote Robinson (The Humanizing of Knowledge) again, an appreciation course should "be so ordered and presented in school and college as to produce permanent effects and attitudes of mind appropriate to our time and its perplexities."

Herbert R. Smith[16] says:

In the vocation of teaching, the foremost objective to be recognized is that the welfare and interests of the pupil are paramount.

In another communication, the same author[17] says:

It is over six years since a committee of the National Educational Association recommended in the reorganization of secondary schools that subjects be taught from the standpoint of their service in life, rather than from the academic arrangement according to logical sequence for the subject's sake.

Not much heed has yet been paid to this advice by the teachers of any subject. In chemistry some promising titles have appeared on the covers of textbooks, but a perusal of the contents brings out the fact that the title is chiefly advertisement.

Caldwell[18] says:

The best education for young people of secondary school age should be best for them whether they go to college or not.... There does not seem to be a need of any reduction in quantity of learning in any special science subject; indeed, it seems likely that the quantity of learning is being considerably increased.... Are the science men, the specialists, really willing to have their subjects changed for the larger usefulness?

Science courses for all the people must help all the people to interpret science for service, not science for power. Service, not power to control, is the needed spirit of modern science instructors.

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[15] THIS JOURNAL, **4**, 1404 (Nov., 1927).

[16] *Ibid.*, **2**, 991 (Nov., 1925).

[17] *Ibid.*, **3**, 565–7 (May, 1926).

[18] "Service, The Needed Spirit of Modern Science Instructors," *School Life*, **10**, 85–7 (1925).

G. W. Hunter[19] shows that the modern tendency in science teaching is really teaching how to live.

Herbert R. Smith[20] says:

> Now, education can be made more attractive and still be dignified. It is not at all necessary to cater to the whims of pupils, *but if teaching is to be effective, it must be taught in terms of the subject's service to mankind.*

In the well-known definition of objectives of secondary education given in the Cardinal Principles of Secondary Education,[21] first place was given to the health objective.

*2. Cognate to the idea of service is the emphasis on the applications of chemistry.*

Gates[22] states:

> For two reasons, we may expect a greater transfer to the activities of daily life from subject matter which is itself directly useful in situations commonly encountered outside of school. First, in order to deal with the situation in life, we need to know the facts involved. Second, the transfer of methods of attack, poise, devices of learning, habits or ideals of caution, accuracy, thoroughness, or initiative to the situations in life will be great to the degree that the subject matter of the classroom is identical with that used in situations which life offers.

Raymond Osborne[23] has given many valuable suggestions which have guided us in the organization of a new type of introductory chemistry course. He summarized his article as follows:

> *First:* Make the application side of chemistry, its connections to industry, to manufacture, to health, and to everyday experience at home and in school, the starting point in as much of our study as possible. Toward this same end, utilize the material in the newer books written to popularize chemistry, stimulating in style, and yet based on sound science.
>
> *Second:* Reduce the number of isolated topics which the pupil must learn by developing a number of new units or topics which will organize naturally and psychologically some of the information now scattered under various elements in isolated paragraphs.
>
> *Third:* Cut out certain topics and increase the amount of attention given to others.
>
> *Fourth:* Topics worthy of attention should be presented fully enough to make a real impression. Establish relationships and connections so that the necessary organization by the pupil will be easy and natural, stimulating rather than destroying interest.

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[19] THIS JOURNAL, **2**, 709 (Aug., 1925).

[20] "The Response of High-School Pupils to Chemical Education," *Ibid.*, **1**, 12–6 (Jan., 1924).

[21] U. S. Bureau of Education, *Bulletin* No. 35 (1918).

[22] "Psychology for Students of Education," 37–72.

[23] "Some Suggestions for Modifying the Content of High-School Chemistry to Better Serve the Purposes of a Liberal Education," THIS JOURNAL, **2**, 737–42 (Sept., 1925).

*3. The scientific method must be emphasized.*

To quote Mr. Morgan[5] again:

> John Dewey, one of the greatest educators the world has produced, has repeatedly stated that science offers nothing so valuable to mankind as a knowledge and appreciation of the scientific method. In one of the most significant books ("The Mind in the Making") that have been published in recent years, James Harvey Robinson maintains that rational thinking (or the scientific method) has contributed more to the advancement of mankind than all other human efforts put together, and that nothing is now so important in education as a knowledge of its past accomplishments and future possibilities. Yet in the report of "A Standard Minimum High-School Course in Chemistry" there is no mention of the scientific method. Apparently, "a prophet is not without honor save in his own country."

Many teachers have salved their consciences with the thought that those students who were taking their technical course in chemistry, but were not going to continue in any work requiring this technical knowledge, would at least gain the scientific habit of thought. This specious argument has been advanced time after time, and yet these teachers know that a course in debating or mathematics would probably give just as good training in the scientific method. The fact that our high schools have failed so signally in teaching the scientific method, using the abbreviated college general chemistry course, leads one to conclude that we have been expecting too much of the usual college course along this line. Unless a conscious effort is made in our textbooks, little will be accomplished in teaching the scientific method.

Dr. F. D. Curtis[24] has shown that definite instruction in scientific attitudes is essential to an adequate training in scientific attitudes, and that it will not come by mere science reading. For that reason, we have devoted a large part of Book I to a study of the development and characteristics of the scientific method. In the latter part of Book I, we have also tried to show how the scientist gains his information, by presenting the facts concerning the nature of the states of matter, following this with the explanation, and repeating this plan with the study of the nature of chemical reactions and its explanation, the nature of the elements, and its explanation, etc.

Some one asked us why we devoted so much space to the study of the scientific method in our study of the particular science, chemistry. He was satisfied when we stated that a fair knowledge of what science is must be obtained before the student is in a position to undertake the study of any one of the divisions of science in an intelligent way; and that, since the student has not been given this understanding previously, it is left for us to do it.

[24] "Investigations in the Teaching of Science," 112–6.

One course in chemistry will never give much training in the scientific method, but if properly presented, it will give an appreciation of the value of scientific training, which will lead to future courses that will afford such training. Too often the present first courses in chemistry merely breed an everlasting hatred of science in general.

Speaking of high-school laboratory experiments, Herbert R. Smith[25] says that the illustrative type, individual and general, is unquestionably the most in vogue at present. The same thing may be said for the usual general chemistry experiments. No wonder students learn little of the scientific method in the first course.

*4. A broad unified view of chemistry must be presented.*

Accordingly, we take Bancroft's[26] definition of chemistry as *the science which deals with all properties and all changes that depend on the nature of the substances concerned.* On the basis of this definition, Dr. Bancroft then points out that everything, except the law of gravitation, the laws of motion, and a few abstract formulations, that give life and interest to physics, is chemistry. He shows that engineering, biology, curative medicine, and geology are really sub-divisions of chemistry.

H. R. Smith[27] says:

> Chemistry is the servant of many other sciences: mineralogy, dietetics, agriculture, entomology, medicine, sanitation, as well as production manufacturing. It is intimately related to industry, to commerce, to the community, and the home. When the student senses these ties of the subject, he begins to see it as capable of making transformations and working scientific wonders as marvelous as ever alchemists dreamed of.

*5. A proper balance of theory and application is essential to an appreciation of chemistry.*

We have allowed our revolutionary tendencies free play in the organization and presentation of this new type of introductory chemistry. On the other hand, we have appreciated the word of caution given by Neil E. Gordon in his editorial on "The New Chemistry,"[28] and have provided for almost all of the "Minimum Essentials" and many of the supplementary topics drawn up by the Committee on Chemical Education appointed by the American Chemical Society.[29] This course organizes the material differently, but otherwise contains all of the material given in the outline for a high-school chemistry course, based on the students' viewpoint, by Currier.[30] except chemical calculations (which are entirely unnecessary).

[25] "The Laboratory Study of Chemistry," THIS JOURNAL, **2**, 231–4 (Apr., 1925).
[26] "The Field for Chemists," *National Research Council Vocational Bulletin.*
[27] THIS JOURNAL, **3**, 104 (Feb., 1925).
[28] *Ibid.*, **4**, 941–4 (Aug., 1927).
[29] *Ibid.*, **4**, 640–56 (May, 1927).
[30] *Ibid.*, **2**, 113–8 (Feb., 1925).

Of the fundamentals of the subject matter of chemistry listed by Mr. R. W. Osborne[31] in a report on this topic, this course provides for every one the 42 applications; for 9 out of the 11 types of chemical change; for 14 out of the 16 theoretical topics; and for 9 out of the 13 laws.

We have attempted to outline a course which, in Dr. Gordon's words, "shall tell what chemistry has done and is doing, but which shall not neglect an explanation of how it is done." It would seem to be impossible to give an adequate appreciation of chemistry without giving at least a minimum understanding of the principles and methods of chemistry.

[31] "Investigations in the Teaching of Science," 145–8.

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**Recommends Cancer Centers for U. S.** Organized cancer centers should be established by the U. S. government, where full-time specialists and research workers will devote themselves to the study of this disease and acquire special skill in its treatment.

This recommendation has just been made to the Senate Commerce Committee by Dr. Ellice McDonald, research worker of Philadelphia.

A special cancer sub-committee of the Senate Commerce Committee will hold hearings soon after the return of the Senate the latter part of August, on the Harris resolution recently passed, calling for the investigation into the whole subject of cancer work with a view to discovering what the United States government should do to further it in this country.

Dr. McDonald's letter calls attention to the cancer work done by the British Empire and Belgium.

In Belgium the requirements for a grant for a cancer center are:

1. Complete surgical service with facilities for consultation for cancer patients.
2. Installation of machines for deep X-ray therapy, consisting of at least two pieces of apparatus, with a minimum capacity of 200 kilovolts.
3. An amount of radium of not less than 500 milligrams.
4. A laboratory where research work, examinations, and necessary analyses for diagnosis and treatment shall be carried out.

In Great Britain, Dr. McDonald points out, financial assistance is given cancer research centers in order to keep them at maximum efficiency. Also individual cancer research workers are given financial support, under approved conditions.—*Science Service*

**Science Most Popular High-School Subject.** Declaring science to be one of the most popular subjects in the high school, Prof. Francis D. Curtis, University of Michigan, told the Science Section of the National Education Association at its Atlanta meeting:

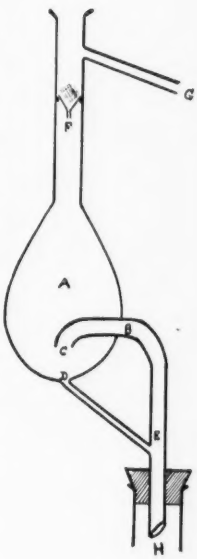
"The past twenty years have witnessed remarkable advances in the improvement of methods and materials for science teaching. These advances have been due to several causes but chiefly to the influence of educational research in helping to determine subject matter and teaching methods better suited to the individual pupil."

Prof. Curtis further explained the popularity of the subject of science by calling attention to the fact that the recently adopted courses in general science give the high-school students an all-round practical training which could not be obtained from the special sciences as formerly taught.—*Science Service*

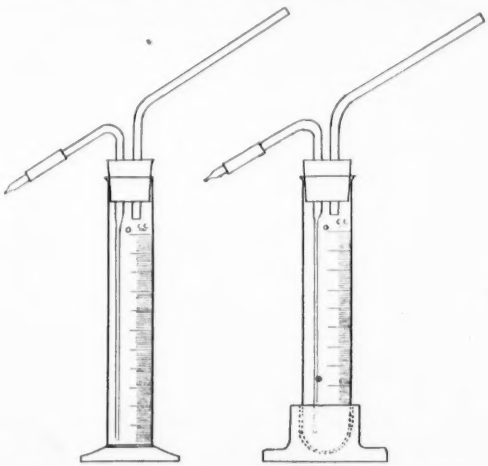
# ABSTRACTS

## APPARATUS AND LABORATORY PRACTICE

**Modification of the Kjeldahl Trap.** G. H. W. LUCAS. *Ind. Eng. Chem., Analyt. Ed.*, **1**, 140 (July, 1929).—In the determination of a few mg. bromine in the presence of a large amount of chlorine, the Br was steam distilled into KI. Even with a Kjeldahl trap some of the oxidizing agent was carried over. A trap as shown in the diagram was devised and found satisfactory. *A* is a 500-cc. Pyrex Kjeldahl flask; *B* is a wide glass tube about 1 cm. bore fused into it; the end *C* is directly over the opening *D;* a small tube 3 mm. bore runs at an angle of about 45 degrees to join *E*. At *F* the sides of the tube are pushed in and a small funnel is thereby suspended; the funnel is filled with glass wool. The tube *G* leads to a condenser. The top of the trap is not sealed off, but is closed with a rubber stopper in order to allow replacement of the glass funnel and glass wool if necessary. During violent ebullition the froth passes up the stem *E* very easily and is directed down. As the tube leading from *D* is small, the gaseous pressure in the flask *H* does not force the liquid back. There is a continual drop of fluid from the flask through *D* back into *H*. This trap is large and is not intended for the ordinary Kjeldahl distillation, but when faced with the problem of distilling a very frothy substance in a Kjeldahl or with steam distillation where the ordinary trap is useless, it is invaluable. D. C. L.




**Simple Graduated Wash Bottles.** EARLE R. CALEY. *Ind. Eng. Chem., Analyt. Ed.*, **1**, 162 (July, 1929).—The bottles are constructed out of a suitable-sized graduate for cold washing or a graduated large-sized test tube for washing with hot water. They are very convenient when it is desirable to know the amount of fluid used in washing. D. C. L.



**Wash Bottles for Special Purposes.** H. YAGODA. *Chem.-Analyst*, **18**, 21 (May 1, 1929).—When it is desired to use but small quantities of the less commonly used washing fluids, the wash bottles from test tubes shown in the accompanying diagrams are recommended.

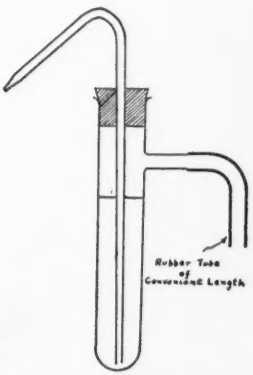



FIGURE 1.—WASH BOTTLE FROM SIDE-NECKED TEST TUBE

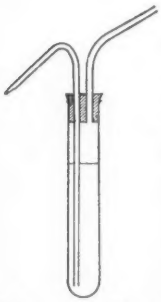


FIGURE 2.—WASH BOTTLE FROM ORDINARY TEST TUBE

"This contrivance will be found useful in the following analytical procedures:

1. Washing precipitates of silver, mercurous and lead chloride with dilute hydrochloric acid solutions in order to decrease the solvent action of the water upon the residue.

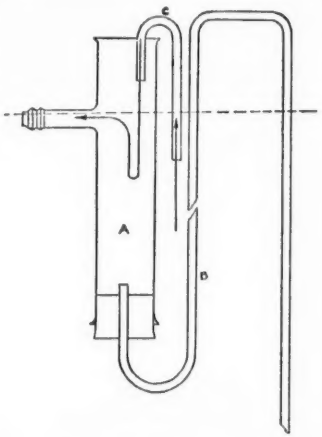
2. In the Group II separation, washing the precipitated sulfides with hydrogen sulfide water prevents the oxidation of copper sulfide to the sulfate.

3. Washing the precipitated sulfides from Group III with a solution of ammonium sulfide and ammonium chloride to prevent the formation of colloids of nickel sulfide.

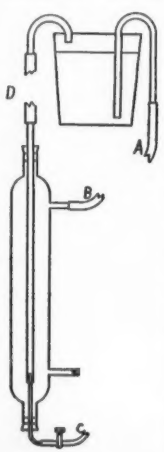
4. In the gravimetric determination of iron and aluminum, the precipitated hydroxides are washed with a dilute solution of ammonia containing ammonium nitrate.

5. For washing potassium perchlorate or chlorplatinate with alcohol in making potassium determinations." D. C. L.

**A Simple Constant Level Water-Bath Regulator.** C. W. EDDY. *Chem. - Analyst*, **18**, 20 (May 1, 1929).—*A* is a glass tube 15 to 20 cm. in length and 3 to 4 cm. in diameter, depending on its use, which has sealed into it near the top a side arm about 5 cm. in length. The author found in his desk a side-arm test tube which was used. The bottom was heated, plunged into water, and the broken end smoothed with a wire gauze. *B* is made of glass tubing and is the siphon. One end is inserted in the stopper in the lower end of *A* and the other end is hung over the side of the water-bath. The lower end must reach about 2–3 inches below the surface of the water in the bath. Tube *C* is the inflow, which is regulated so it allows less water to enter the tube *A* than can be carried away by the side arm.




Tube *A* is then raised or lowered until the water level (the dotted line in the diagram) is adjusted to the proper level. The tube *B* is then filled with water and the level will remain constant as long as water is allowed to flow through tube *C*. Any increase of water in *A* will cause the water to flow through *B* into the bath and, conversely, any increase of water in the bath will cause the water to flow through *B* until the two water surfaces become level again. D. C. L.



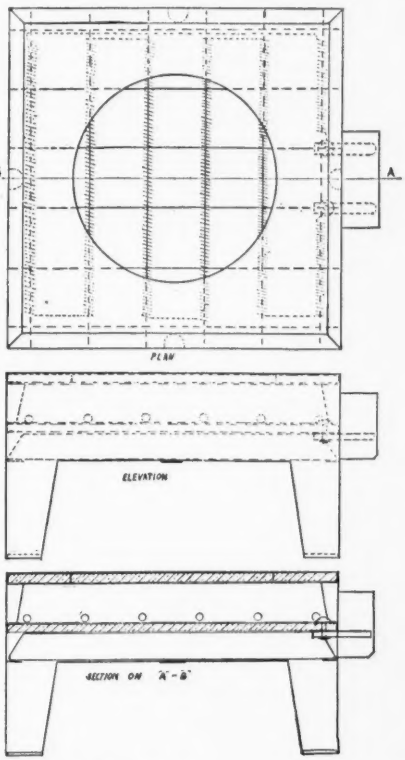

**A Brine Circulator for Cooling Condensers.** H. T. GERRY. *J. Am. Chem. Soc.*, **51**, 475 (Feb., 1929).—"In working with low-boiling compounds it has been found advisable at times to circulate cold brine through the jackets of the condensers. Such circulation may be made continuous by the use of a simple modification of the "air lift" pump used in some sulfuric acid plants. The system gives excellent cooling and requires no attention.

"The pump consists of an old condenser jacket with the lower side arm plugged up. A piece of glass tubing of about 6 mm. diameter is passed through the stopper in the top of the jacket and reaches almost to the bottom. Through the stopper in the bottom of the jacket a piece of small glass tubing of such size that it will not plug up the 6-mm. tube is passed and reaches about 2 cm. into the 6-mm. tube. This small tube is connected to an air blast tap by a rubber tube *C* with a pinchcock on it to regulate the flow of air. The top side arm of the jacket is connected by rubber tubing *B* to the outlet of the condenser to be cooled, and the 6-mm. tube is connected by a rubber tube *D* to a piece of bent glass tubing hooked over the edge of a pail. This tube *D* should be ver-

tical or nearly so throughout its length. The pail is filled with concentrated brine and ice and the siphon *A* is connected to the inlet of the condenser to be cooled. The height of the water level in the pail should be about four feet above the bottom of the pump, which may be suspended vertically over the edge of the laboratory bench.

"In order to start the circulation of the brine both the condenser to be cooled and the pump are filled with brine and the air is then regulated so that a steady stream of bubbles passes up the tube. The condenser jacket can be kept below zero in this manner without any difficulty whatsoever." R. L. H.

**A Laboratory Heater.** L. J. N. MOTHERSILL. *Chem.-Analyst*, **18,** 17 (May 1, 1929).—The heater recommended is made from one of the cheap toaster stoves on the market, costs about $1.25 and can be easily made by the students. The accompanying drawings may be of some help in following the instructions below.




"The bottoms of these stoves are usually held in place by means of four ears. These are bent back and the bottom, element, spacer, and screen removed. If the heater is to be used for distillation work only the screen may be discarded but if the heater is to be a general purpose one the screen is retained as a support for beakers, etc. A piece of asbestos board 1/8" thick is cut to fit the top of the heater (the same size as the element board) and a hole 3" in diameter cut in it.

"It is then put in place, next to it the screen (if it is to be used), then the spacer element and bottom. It may be found necessary to cut away part of the side of the heater as the element terminals will be somewhat lower down.

"When apparatus requiring a smaller aperture than 3" is to be used boards may be provided having different sized holes. The temperature may be controlled by an exterior rheostat." D. C. L.

**A New "Dry-Ice" Machine for the Laboratory.** *Laboratory*, **2,** 42–3 (1929).—The Carbo-Freezer described consists essentially of a stand for supporting the cylinder of carbon dioxide gas, a calcium chloride drying tower for removing any water vapor in the gas, and the freezer proper. The complete apparatus costs one hundred and fifty dollars. Solid carbon dioxide snow can be automatically and instantly produced, and without any inconvenience.

"Some of the uses to which the Carbo-Freezer has been put in the laboratory are: low-temperature crystallization, removal of naphthalene from solvents, freezing-point, cloud- and pour-point, and dew-point determinations, gas analysis, determination of gasoline in natural gas and of light oil constituents in by-product gas from coal distillation, paraffin determination in light oils and lubricants, vapor pressure determinations.

"Other uses to which the Carbo-Freezer is being put is the preservation of biological specimens during storage before analysis, the preservation of water samples, the prevention of putrefaction, the preparation of "frozen sections" for microscopical examination, the storage of butter, ice cream, and other foods during transportation, investigation of weathering of paints, varnishes, cements, and determination of fatigue of metals at low temperature." R. L. H.

**A Temperature Regulator for Carius Furnaces.** G. B. HEISIG. *J. Am. Chem. Soc.*, **50,** 3388 (Dec., 1928).—"The constant attention necessary to regulate the temperature of an ordinary gas-fired Carius furnace may be avoided by equipping it with a thermostat used to control the temperature of ovens on gas cooking stoves. Such a thermostat (supplied by the Kraus Mfg. Co.) is very easily installed, inexpensive, and is accurate to about 5°. The approximate range of the device is 100–325°.

"The only precaution to be observed is not to turn the burner on full if, for example, a temperature of 100° is required, for the heat from the walls of the furnace will raise the temperature above 100° even after the thermostat has reduced the flame. The burner should be turned on approximately as it would be if no regulator were being used.

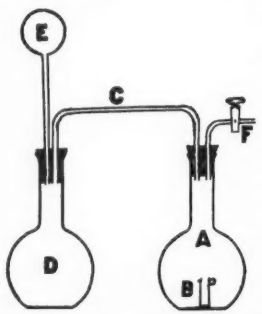
"Thermostats of this type should be satisfactory for controlling the temperature of other gas-fired furnaces used in chemical work." R. L. H.

**An Acid Digester.** H. YAGODA. *Chem.-Analyst*, **18,** 18 (May, 1929).—When a substance is to be digested with a specified amount of acid, and then diluted to give a desired acidity as in certain qualitative procedures, loss of acid can be cut down by placing an evaporating dish filled with cold water over the beaker in which the digestion is carried out. D. C. L.

**Rapid Calibration of Pipets and Burets.** A. T. SHOHL. *Ind. Eng. Chem., Analyt. Ed.*, **1,** 152 (July, 1929).—Tared flasks are placed on the balance pans, the weights corresponding to a known volume of liquid are added, and Hg covered with water is added from the object to be calibrated. The points to be marked are indicated by the water meniscus. If too much mercury has been run into the flask, it may be withdrawn with a dropper and returned to the apparatus. After one determination the Hg is poured out, and the flask is ready for the next determination. D. C. L.

**To Remove Grease from Buret Tip.** C. J. SCHOLLENBERGER. *Chem.-Analyst*, **18,** 15 (May 1, 1929).—To remove grease, during a titration, from a plugged buret tip, rapidly pass under it several times a match flame. Open stopcock at once and melted lubricant will be immediately expelled. This method is superior to the fine wire method usually resorted to. D. C. L.

**A Simple Apparatus for the Determination of Carbon Dioxide.** R. C. WILEY. *J. Am. Chem. Soc.*, **51,** 222–3 (Jan., 1929).—"Set up the apparatus as shown in the figure and make sure that it is airtight. Weigh out 0.1000 g. of carbonate into *B*, place 100 cc. of a 1% aqueous solution of chromic anhydride in *A* and 50 cc. of water in *D*. Heat the contents of both *A* and *D* to boiling, remove both flames and add 25 cc. of a 0.2 *N* barium hydroxide solution to *D*. Carefully lower the bottle *B* containing the charge into *A* with a copper wire without letting the acid come in contact with the carbonate. Quickly stopper both *A* and *D*, which are thus connected by the tube *C*. Shake flask *A* to overturn *B*, place *D* in cold water and boil the contents of *A*. The balloon *E* serves as a safety valve, pressure regulator, and pressure indicator. After boiling for about 30 minutes, remove the flame from beneath *A* and admit carbon dioxide-free air through *F*. The flask *D* should be now at about room temperature. Disconnect it and titrate the excess barium hydroxide with standard hydrochloric acid, using phenolphthalein as indicator.

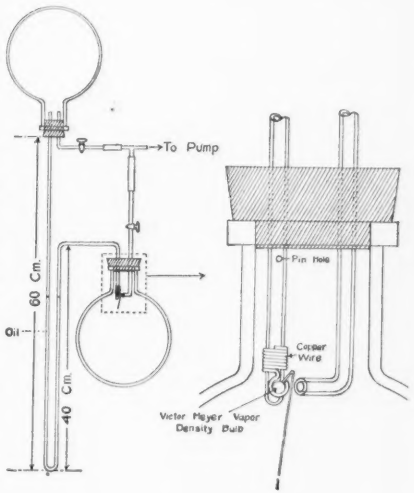



"The advantages of the method are that no train is necessary and the apparatus is cheap and easy to set up. It is likewise easy to clean. The results obtained are quite accurate." R. L. H.

**A Method for Determining Vapor Densities at Room Temperatures.** E. F. LINHORST. *J. Am. Chem. Soc.*, **51,** 1165–7 (Apr., 1929).—Two 2-liter round-bottomed flasks connected by an oil manometer (5-mm. inside diameter and 60 cm. length) are evacuated simultaneously through a T-tube, the arms of which are provided with stopcocks and each connected with one of the flasks. The sample is sealed up in a Victor Meyer bulb, which is then hung in a loop formed by one end of a stiff copper wire coil wrapped around the sealed end of the oil manometer (in which a small hole is blown just below the rubber stopper), projecting 4 in. into one of the flasks. The flasks are evacuated to about 1 cm. of mercury, and the cocks closed. The bulb containing the liquid is then crushed against the manometer tubing by an angle bent at the end of the stem of the stopcock, which is joined to the T-tube outside. After a few minutes the temperature

and increase in pressure are read, and the molecular weight ($M$) may be calculated from the equation $PV = WRT/M$. The minimum vapor pressure of the sample should be 4 cm. of mercury at room temperature or larger flasks, or a higher temperature, must be used. The main precaution to be observed is not to warm the flask with the hands. R. L. H.

**A Simple Method for the Determination of $C_p/C_v$ (as a Lecture Experiment).** E. RUCHARDT. *Physik. Z.*, **30,** 58–9 (1929); *C. A.*, **23,** 2612 (June 10, 1929).—A glass tube 55 cm. long, and of a uniform 1.6 cm. inside diameter is passed through a rubber stopper into a 5–6-liter bottle with bottom tubulature, containing the gas. On dropping a perfectly spherical steel ball of diameter appropriate to the tube into the latter, the ball oscillates in the tube with a period of about 1 sec. By measuring the period for one vibration with a 0.1 sec. stop watch, and substituting in the formula (derived), the ratio $C_p/C_v$ is determined.




$$\frac{C_p}{C_v} = k = \frac{4\pi^2 mv}{q^2 pT^2}$$ where $m$ = mass of ball; $V$ = vol. of bottle in cc.; $q$ = cross-section of tube (in. sq. cm.); $b$ = bar. pressure (in. cm.), $T$ = period, $p = b + \frac{mg}{q}$ $g$ = gravitational constant. The method provides a rapid and accurate means of measuring $C_p/C_v$, and also offers visible proof of the adiabatic elasticity of gases. For air, $k = 1.39$ instead of the usual 1.40; for wet $CO_2$, $k = 1.27$ instead of 1.30. C. E. M.

**The Confirmatory Test for Aluminum.** R. GEMMILL, R. BRACKETT, AND C. R. MCCROSKY. *J. Am. Chem. Soc.*, **51,** 1165 (Apr., 1929).—The procedure recommended for carrying out the test for aluminum is as follows: "Pure asbestos fiber, one-half the size of a pea, was looped in platinum wire, dipped into a solution of 0.05 $N$ cobalt nitrate, ignited, then dipped into the solution of the aluminum hydroxide precipitate (dissolved in the least amount of nitric acid) and ignited."

The test is sensitive to 0.2 mg. of aluminum, the sodium salts do not interfere, and the same test may be applied successfully for 0.5 mg. of zinc. R. L. H.

**Identification of Rayon.** W. D. GRIER. *Ind. Eng. Chem.*, **21,** 168–71 (Feb., 1929).—Microscopical examination of the fibers, and particularly of their cross-section, affords a reliable means of distinguishing between the four general types of artificial silk now on the market, namely, viscose, cuprammonium, nitro, and acetate silks. The first three also polarize brilliantly, acetate silk only feebly. As regards chemical tests, nitro silk gives a very distinct reaction with diphenylamine and sulfuric acid reagent, and viscose may be detected by a test proposed by Screiber and Hamm, which depends on the formation of minute residual amounts of sulfur compounds when the material is heated on a steam-bath with very dilute sulfuric acid. Acetate silk dissolves readily in acetone. D. C. L.

**The Use of Aluminum for the Detection of Arsenic.** E. B. SVENSON. *Chem.-Analyst*, **18,** 5 (May, 1929).—Suggests the use of Al in place of Zn, since all virgin Al is free from As. If used with sulfuric acid, the Al must first be activated by treating with a Hg or Cu salt. D. C. L.

**Determination of the Moisture Content of Coal and Similar Substances.** M. MANNHEIMER. *Ind. Eng. Chem., Analyt. Ed.*, **1,** 154 (July, 1929).—None of the methods ordinarily used seems completely satisfactory. By the method here described a determination can be made in 5 minutes. It consists of the extraction of the coal with a hygroscopic liquid and the subsequent determination of the water content of the liquid. Of the liquids considered, methanol appeared most satisfactory. The methanol extract had but slight yellow color due to extraction of other substances. The finely powdered

coal is shaken for half a minute with a known volume of methanol, and after filtration the moisture content determined. It was found most convenient to use a glass floater having the same density as the absolute methanol at a certain temperature, and it will then sink at a higher temperature and rise at a lower. The temperature of the extract is so adjusted that it will just float. The change in temperature is a measure of the water content.

A complete account of the technic, a diagram of the apparatus, and the results of several determinations are given. D. C. L.

**Preservation of Anesthetic Ether.** C. L. HEWER. *Lancet*, **1929,** 770–1; *Analyst*, **54,** 352 (June, 1929).—"The oxidation to which ether is prone may be prevented by treating the ether with carbon dioxide and then storing it in copper containers. When anesthetic gases are bubbled through ether for long periods, the rate of decomposition of the ether will be greatly diminished if there is an adequate area of copper both above and below the surface level of the liquid." R. L. H.

**Note on the Recovery of Platinum.** G. J. HOUGH. *Ind. Eng. Chem., Analyt. Ed.*, **1,** 162 (July, 1929).—Gives a brief account of the treatment of the filtrate from chloroplatinates to recover both alcohol and Pt. By this method it is shown that a solution used in a total of 200 determinations and passing through 7 recovery treatments had lost only 200 mg. Pt, or a loss of less than one-fourth of a per cent determination. D. C. L.

**Handy Cork Gage.** R. B. WAILES. *Chem.-Analyst*, **18,** 20 (May 1, 1929).—Several trials usually have to be made in selecting corks from the cork bins to fit a bottle or flask, before the wanted size is found. By keeping a string of corks, each one numbered with its size, in the drawer containing the bins for corks, a standard of reference can always be had without selecting two or three before the size wanted is desired.

By fitting the flask or container with one of the corks upon the string, the exact size is ascertained, and from this the cork is ordered from stock, or the chemist himself can go to the exact cork for the exact size. D. C. L.

## TEACHING METHODS, AIDS, AND SUGGESTIONS; CURRICULA

**Research Method of Teaching Science.** J. M. ANDERS. *Gen. Mag. & Hist. Chron.*, **31,** 479–88 (July, 1929).—The present status of science teaching in American colleges and universities, though by no means to be viewed with alarm, is far from being wholly satisfactory. An ideal condition would demand that every teacher should be an investigator in his particular field. It is contended with reason that a readjustment of the college curriculum in such manner as to bring about the adoption of research method of study, together with a corresponding lessening of the adoption of ready-made facts by the student, is of pressing importance. The time is ripe for a movement on the part of our colleges away from a purely pedagogic to a virile, intellectual atmosphere; for the passage from the older descriptive method to the newer experimental phase of education. Henry Ford is of the opinion that we are at present entering upon an era of great industrial development which he avers will be led by trained scientists. College authorities no longer need to hesitate to assign science its proper position on the roster on religious grounds, since it has been readjusting itself to spiritual thought in such a manner as to preclude the possibility of its destroying reverence and faith. Students whose ambition begets a desire to take up original research should be given free reign to prove the genius that inspired their predilection for this method of study. Some of these students, even if denied an opportunity at college, would no doubt pursue their way, later in life, toward the goal they had set for themselves, but they might justly feel aggrieved at the enforced pause in their progress. In the past, science has not kept pace with the teaching of the humanities in the colleges. Wise financial planning of a college should include the creation of an endowment for its research department. The changed order of things educational will, doubtless, cause those institutions which do not foster research to vanish like a "creed outworn." J. H. G.

**Industries and Schools Confer on Engineer's Education.** EDIT. *Chem. & Met.*, **36,** 401 (July, 1929).—The third conference on chemical engineering education was held in Philadelphia, June 22nd, under the auspices of the American Institute of Chemical Engineers. Some of the topics discussed were (1) the purpose and use of the chemical engineering laboratory, (2) introducing the student to industrial work, (3) a system of personal rating and character analysis, (4) the place of economics in the chemical engineering curriculum, (5) an industry's appraisal of the chemical engineering graduate, (6) mathematics for chemical engineers, and (7) the character of post-graduate work for chemical engineers. R. L. H.

**Education of the Research Chemist.** COMMITTEE REPORT. *News Ed., Ind. Eng. Chem.*, **7**, 1 (July 10, 1929).—In this report by a sub-committee of the Executive Committee of the Division of Chemistry and Chemical Technology of the National Research Council is presented an outline of the type of education and training desirable for the chemical research worker in industry. R. L. H.

## KEEPING UP WITH CHEMISTRY

**We Demand System Even in the Realm of Literature.** KUTZNER. *Chem. Fabrik*, 1929, 1–2.—Here is offered a plea for better technical articles on behalf of the person only generally interested in a certain field related to his own specialty, who must usually resign himself to the laborious task of reading through the entire contents of journals in order not to miss any details of importance to him and often finds himself involved in technical terminology which may not immediately suggest its relation to what he seeks.

In regard to externals, paragraph headings in black type which may be taken in at a glance would save much time in orientation and in detection of the necessary material. Concerning the contents of the article: the following points should be covered in a description of a new apparatus; purpose, applications already made and results obtained, manner of operation, labor and supervision needed, quality of product, size and weight of apparatus, output, space requirement, motive power, heat and power consumption, probable repairs, construction in detail (with exact drawings), material used, patent information, and other possible uses. New materials should be compared with known ones; physical and chemical properties, uses, handling, working, and forming should be described and full patent information given.

Conformity to these suggestions would insure that none of these important data would be omitted and their account in concise outlined form would save much time in searching for information. C. E. M.

**Modern Methods of Cleaning Air.** P. DRINKER. *Harvard Alumni Bull.* **31**, 669 (Mar. 7, 1929).—*Abstract of a lecture.* One of our most serious industrial and household problems today is the elimination of air-borne dust and dirt. Whether the dustiness is a menace to health, or whether it is simply a nuisance, we object equally to its presence in large amount. Every one knows that a house shut up during the summer requires dusting and cleaning when opened in the fall. This dust was brought in by the air currents leaking around the doors and windows and coming down the chimneys of open fireplaces.

In our large cities, new buildings are generally equipped with devices for cleaning the air which is introduced for ventilation. In factories or mines, dust-collecting devices of various sorts are found—some for collecting dusts which are dangerous to breathe, such as those containing lead compounds or quartz, and some for relatively harmless dusts, like coal.

To the householder, excessive amounts of any dust, or black smoke in the air, create a serious inconvenience. They increase his laundry and cleaning bills, damage his furnishings and discolor his house, both inside and out. Many of us were surprised recently, for example, to see the red brick walls of the Hotel Touraine in Boston emerge from the hands of the sandblaster.

Several types of air-cleaning or dust-removing apparatus are in use today. This article describes five modern types of dust remover.

1. *Dust Collector Type.* Air pipes containing the dust enter a collector. The air, slowed up, can no longer hold the dust in suspension.
2. *Bag Filter Type.* Similar to that of the ordinary vacuum cleaner. When the bags become plugged up they are cleaned by shaking either automatically or by hand.
3. *Cottrell Precipitator.* If the dust is valuable it can be caught by a process involving the use of a high tension (20,000 to 75,000 volts) electric discharge. Process very efficient but expensive.
4. *Washing Air by Water Sprays.* Less efficient than the electrical method, due to the carrying over of dust through the bubbles.
5. *Viscous Filter.* If dusty air is carried through steel wool coated with a non-volatile oil, dust particles are caught on the oily wool. Many other substances may be used instead of the steel wool in these "viscous filters," but they all give the air a tortuous path and impose a sticky surface to catch the dust particles. S. W. H.

**More on the Ultra-Violet.** *Technology Rev.*, **31**, 279 (Mar., 1929).—Indiscriminate use of ultra-violet light produced by the many lamps now sold to the public has been tempered, it is hoped, by recent admonitions voiced by physicists and physicians who at first suspected and now have pretty tangible proof that injury may result. An active side issue has developed over certain allegations that ultra-violet-transmitting glass

gradually loses its transmitting quality, becomes "solarized," after a period of time.

Donald C. Stockbarger, '19, assistant professor of physics at Massachusetts Institute of Technology, who, in *The Review* for November, effectively pointed out the dangers of artificially produced ultra-violet light, recently has refuted the assertion that ultra-violet-transmitting glass finally becomes impervious to these short waves. In a paper prepared for delivery before a conference of the National Housing Association at Philadelphia on January 30th, he said: "Whoever invented the solarization bugaboo evidently did not know that such processes slow down very rapidly so that after a short time they come to a standstill. I have here some specimens of ultra-violet-transmitting glass which has been solarized to the limit. I know that the limit has been reached because they were tested from time to time during the solarization process and those tests proved conclusively that depreciation stopped soon after it began. It seems safe to say that any of the better materials offered by responsible makers will give excellent service as long as you care to use them. . . . Finally, I want to emphasize the importance of making use of this natural health-maintaining agent [the sun]. . . to let sunshine into the house in all its natural ultra-violet quality is now a relatively simple matter. Windows, for example, can be made wider and higher and can be placed in unconventional locations if doing so will prove advantageous. Particularly would I suggest that skylights be used wherever possible, for a few of these could let in more health rays than all of the rest of the windows combined. . . .

"The ideal ultra-violet home, I think, would be one in which the conventional order of the present was reversed in so far as location of rooms is concerned. I would place sleeping chambers, kitchen, and dining room on the ground floor, leaving the second floor for the living room, study, playroom, or nursery. By the use of windows and sky-lights fitted with ultra-violet-transmitting glass those rooms in which we spend most of our time would thus have the greatest benefit from the sunlight." S. W. H.

**A Table of Electrochemical Equivalents. Based on 1929 Atomic Weights.** G. A. ROUSH. *Trans. Am. Electrochem. Soc.*, **55** (preprint), 11 pp. (1929) (also in pamphlet form); *C. A.*, **23**, 2889 (June 20, 1929).—The last complete table of electrochemical equivalents is that calculated by Hering based on 1917 atomic weights. Since that time there has been a large number of revisions in atomic weights, some of them of considerable magnitude. The entire list was therefore recalculated to 5 decimal places on the basis of the 1929 atomic weights. C. E. M.

**Chemistry and Materia Medica.** ANON. *Chem. Age*, **20**, 614–5 (June 29, 1929).—*A review of a lecture delivered by R. R. Bennett.* Some of the factors which are responsible for the higher average level of health today, in spite of increased physical and mental strain of modern life, are briefly outlined. Among others there are mentioned isolation of active principles from natural drugs, synthetic drugs, mercurochrome, and other antiseptics. E. R. W.

**Chemistry, Agriculture, and Industry in Germany.** W. A. DYES. *Chem. & Ind.*, **48**, 507–10 (May 17, 1929), 528–31 (May 24, 1929).—"Competition means progress, but overproduction and price-cutting can be disastrous. . . . The formerly flourishing rayon business is now passing through critical stages in many countries."

"The export trade of the United States depends to the extent of 45% on sales to Europe, but European sales to the United States are barred by high duties."

Besides discussions suggested by the above extracts the article gives a rather detailed summary of the condition of industrial chemistry and agriculture in Germany at the present time. E. R. W.

**Manufacture of Carbon Dioxide.** H. E. HOWE. *Ind. Eng. Chem.*, **20**, 1091–4 (Oct., 1928).—This article describes the plant of the Dry Ice Corporation at Elizabeth, N. J. The process of manufacture of carbon dioxide snow is given in detail, the description being accompanied by an explanatory flow chart.

"During the past few years there has been a steady growth in the demand for this material based on the convenience attending its use and the special applications to which it may be put. Today a certain frozen confection is dispensed largely from one-gallon vacuum jugs where the temperature is kept satisfactorily low with one pound of the refrigerant per day. Fresh meat and ice cream are being distributed by trucks cooled with solid carbon dioxide and no longer leave a trail of salt water on the pavement. Food specialties are being regularly shipped over long distances in specially designed containers. A development department of the company is busily engaged on a number of projects dealing with new uses, and particularly with improvement in devices in which the new refrigerant can be used to the most economical advantage.

"However, the established demands already tax the capacity of the company's facilities. The plant in Yonkers, utilizing by-product gas from molasses fermenters,

continues in operation with a capacity of some 10 tons per day. The Chicago plant produces 5 tons per day and will be enlarged. It is expected that the plant described in this article will soon be greatly expanded by the addition of further units in which will be embodied new methods both of construction and operation established through research in which the company is continually engaged. Each unit consists of a coke-fired boiler, two scrubbing towers, two absorber towers, a heat interchanger, a lye boiler, and cooling coils. The compressor room works on gas from a common header of gas from a holder, so that the enlargement of the plant can go on without any interference with established operating units.

"The last two years have seen carbon dioxide greatly emphasized as a commercial gas. We have long been familiar with the steel cylinders which in themselves have represented a considerable annual tonnage of output. But now that its place as a commercial refrigerant has become established, it seems but a question of time when demand will require plants for production of solid carbon dioxide as widely and conveniently distributed as are those for the production of the indispensable soda fountain accessory and of a size comparable with other units of the chemical industry."

D. C. L.

**Preparation and Industrial Use of Solid Carbonic Acid.** R. PLANK. *Z. Ver. deut. Ing.*, **73**, 221–4 (1929).—The article is a review of American practice in the preparation and use of solid $CO_2$ or dry ice and is essentially the same as an article by Howe in the October, 1928, number of *Industrial and Engineering Chemistry*. [See Abstracts, THIS JOURNAL, **6**, 1826 (Oct., 1929)]. An account of its manufacture and a discussion of its properties are given together with its advantages over ice as a refrigerant, the most noteworthy of these being the economy of space, the fewer number of required reloadings (of advantage to freight car operators), and the more sanitary conditions and decreased corrosion due to the elimination of water. The convenient use of solid carbon dioxide in the shipment of sea-food, ice cream, and other perishable food products in small containers is pointed out, this being of economic significance in Germany. Although in that country, the present-day price of liquid carbon dioxide makes the cost of industrial use prohibitive, the author points out that a great portion of the cost is due to the use of steel containers which add to the cost of shipment and which are eliminated in the shipment of the solid carbon dioxide. Results of experiments which show solid carbon dioxide to be not much more expensive but very much more advantageous than ice are given.

C. E. M.

**Dry Ice, The New Refrigerating and Preserving Agent and Its Production.** A. KARSTEN-SALMONY. *Chem.-Tech. Rundschau*, **44**, 275 (1929); *C. A.*, **23**, 2536 (May 20, 1929).—The characteristics of commercial solid $CO_2$ are described, as well as the method of its production by the Carba Akt.-Ges. of Bern. This method consists in chilling at a pressure of over 5 atm. and yields a solid of sp. gr. 1.4–0.5. This is contrasted with other processes which yield first a somewhat spongy $CO_2$-snow, which must be further compressed.

C. E. M.

**High Pressures in the Manufacture of Synthetic Ammonia.** ANON. *Chem. & Ind.*, **48**, 591–8 (June 14, 1929).—A discussion of the Haber process and the Claude modification of this process for the manufacture of ammonia. The article deals especially with the development of the high pressures necessary for efficient manufacturing. Compressors working at 14,000 lb. per sq. in. are now in operation.

E. R. W.

**Tungsten as a Technical Material.** ANON. *Chem. & Ind.*, **48**, 573 (June 7, 1929).—The metallurgy of tungsten is briefly described. Nickel and copper surfaces may be coated with tungsten by electrolytic deposition from an alkaline electrolyte. Beside the common uses of tungsten in lamps and in carbon electrodes it is important in the preparation of alloys, conferring hardness and resistance to acid corrosion.

E. R. W.

**Northern Rhodesia Rich in Copper.** O. LETCHER. *Compressed Air Mag.*, **34**, 2801–5 (July, 1929).—The large deposits of copper ore in Rhodesia are of interest to the people of the United States because of the lead in the copper industry which we have so far maintained. Much American capital and machinery are being used in the development of this new field. Production, at present amounting to only 7000 tons per annum, is expected to increase to 150,000 tons in four or five years' time. The history of the discovery and development of the Rhodesia copper country is presented in an interesting, well-illustrated article.

E. R. W.

**The Production, Properties, and Uses of Special Brasses.** ANON. *Chem. Age (Mo. Met. Sect.)*, **20**, 41–2 (June 1, 1929).—A classification of the different types of brasses, and a brief discussion of the effect of adding different elements on the properties of brass.

E. R. W.

**Emulsified Asphalts (Asphalt Emulsions).** E. S. ROSS. *Chem. & Ind.*, **48**, 112T–

14T (May 17, 1929).—An interesting discussion of the application of theoretical colloid chemistry to the preparation of asphalt road-making material. In order to prepare an emulsion suitable for road building, the interfacial tension between asphalt and water must be lowered by some soap, the mixture should be slightly alkaline, some protective agent such as fine clay should be added. E. R. W.

**The Exploitation of the Dead Sea.** I. MELAMEDE. *Chem. Age*, **20,** 558–60 (June 15, 1929); 582–3 (June 22, 1929).—An interesting and authoritative account of the resources of the Dead Sea. The waters of this sea contain 2000 million tons of potassium chloride, 980 million tons of magnesium bromide, 11,900 million tons of sodium chloride, 22,000 million tons of magnesium chloride and 6000 million tons of calcium chloride. The method by which this immense wealth of raw material may be exploited, using only the sun's heat to evaporate the water, is outlined. E. R. W.

**Facts and Fancies about Gas Warfare.** EDIT. *Technology Rev.*, **31,** 213 (Feb., 1929).—"Deadly gases purported to have sufficient toxicity to wipe out whole cities are periodically discovered, according to the public press, and it has grown to be the great indoor sport of a school of front-page chemists to draw horrific pictures of the use of gas in the next war. A ready-made example of this is available in a public statement emanating from Hilton Ira Jones of Chicago, listed in the Directory of the American Chemical Society as Director of Scientific Research, The Redpath Bureau. He is quoted as asserting that the government possesses knowledge of a new gas believed by him to be cacodyl isocyanide, which is so overwhelmingly deadly that the Chemical Warfare Service of the Army has attempted to suppress discussion about it.

"At best Dr. Jones' statement is an ill-informed outburst, adding to public fear and misunderstanding of lethal gases and their military uses. It is a generally accepted maxim among informed chemists and physiologists that no gas exists at the present time (nor will one be discovered) for which some means of protection and defense may not be devised. Professor James F. Norris, Director of the Institute's Research Laboratory of Organic Chemistry, and former President of the American Chemical Society, on talking recently of the development and use of war gases, stated that the gas referred to by Dr. Jones was tested exhaustively by the Germans (Just and Haber worked at it) during the World War but was not used by them. Dr. Norris, who was in charge of offense chemical research and war gas investigating for the United States Government during the war and is now a consultant for the Edgewood Arsenal, holds that the Allies were also familiar with the cacodyl group and found it unsatisfactory. Thus, it seems, there is nothing particularly new or startling about the gas to which the Chicago chemist refers.

Moreover, as Dr. Norris points out, it is improbable that more deadly or toxic gases will be discovered; enough sufficiently lethal gases are already known. Asphyxiant gases such as phosgene ($COCl_2$) and blistering gases such as mustard gas (dichlorethylsulfide) will certainly kill if they make contact in sufficient quantities. Instead, the probable trend of gas warfare studies will be toward finding more effective means of using these known gases against the increasing effectiveness of methods to combat them, and in the development of so-called neutralizing gases which incapacitate rather than kill. Anyhow, it is patently absurd to say that any gas could be used in quantities sufficient to annihilate whole populations and altruism of the sort implied by Dr. Jones would be obviously incompatible with faithful adherence to the responsibilities the Republic has entrusted to its Chemical Warfare Service. S. W. H.

## HISTORICAL AND BIOGRAPHICAL

NOTE: References which are consulted for the material on the frontispieces to THIS JOURNAL will be recorded hereafter in this section of the Abstracts each month.

**Van't Hoff Memorial Lecture.** J. WALKER. *J. Chem. Soc.*, **101,** 1127–43 (1913).—An account of the life of van't Hoff and his contributions to chemistry. M. W. G.

**Jacobus Henricus van't Hoff.** B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., New York City, **1927,** 2nd edition, pp. 79–109. M. W. G.

**Van't Hoff—His Work.** B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., New York City, **1927,** 2nd edition, pp. 337–55. M. W. G.

**Jacobus Henricus van't Hoff—Sein Leben und Wirken.** ERNST COHEN. Leipzig, Akademische Verlagsgesellschaft m. b. H., **1912.** M. W. G.

**Jacobus Henricus van't Hoff.** ANON. *Sci. Mo.*, **7,** 563–4 (1928).—Biographical note. M. W. G.

**Van't Hoff in America.** B. HARROW. *Sci. Mo.*, **7,** 564–8 (1918). M. W. G.

**Stereochemistry and Technics.** P. WALDEN. *Z. angew. Chem.*, **38,** 429–39 (1925).—A thorough review of the history and the modern application of stereochemistry with biographical note on van't Hoff and Le Bel. M. W. G.

**Emil Fischer—Sein Leben und Sein Werk.** K. HOESCH. *Ber.*, **54,** special number, 480 pp. (1921). M. W. G.

**Emil Fischer Memorial Lecture.** M. O. FORSTER. *J. Chem. Soc.*, **1920,** 1157–201.—Contains a biographical note and a thorough survey of Fischer's invaluable work in organic and biological chemistry. M. W. G.

**Commemoration Speech on Emil Fischer.** BECKMANN. *Sitzber. preuss. Akad.*, **1920,** 698–703. M. W. G.

**Prof. Emil Fischer.** *Nature*, **103,** 430–1 (1919).—An obituary. M. W. G.

**Emil Fischer.** P. JACOBSON. *Chem.-Ztg.*, **43,** 565–9 (1919).—Obituary. M. W. G.

**Emil Fischer's Recollections.** W. J. POPE. *J. Soc. Chem. Ind.*, **41,** 495–6R (1922). M. W. G.

**Emil Fischer.** *Proc. Roy. Soc.* (London), **98A,** 1–lvii (1921).—An outline of Fischer's work. M. W. G.

**Emil Fischer.** B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., New York City, **1927,** 2nd edition, pp. 217–39. M. W. G.

**Fischer—His Work.** B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., New York City, **1927,** 2nd edition, pp. 440–58. M. W. G.

**Adolph von Baeyer.** F. A. MASON. *Sci. Progress*, **12,** 489–90 (1928).—Biographical sketch and obituary notice. M. W. G.

**Baeyer Memorial Lecture.** W. H. PERKIN. *J. Chem. Soc.*, **1923,** 1520–46.—An account of Baeyer's life and his contributions to chemistry. M. W. G.

**Moissan Memorial Lecture.** W. RAMSAY. *J. Chem. Soc.*, **101,** 477–88 (1912).—An account of Moissan's life and work with portrait. M. W. G.

**Henry Moissan.** B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., New York City, **1927,** 2nd edition, pp. 135–54. M. W. G.

**Hideyo Noguchi, A Biographical Sketch.** S. FLEXNER. *Science*, **69,** 653 (June 28, 1929). G. H. W.

**Missionaries of Science—Elihu Thompson and William Stanley.** E. W. RICE, JR. *Gen. Elec. Rev.*, **32,** 355–61 (July, 1929).—Missionary! What a picture that word brings to one's mind! He is a man who strives to lift his fellowmen from the depths of ignorance; who pushes back the border of the unknown; and who is "inspired by something finer than the desire for fame or power or money." Elihu Thompson and William Stanley were missionaries—"missionaries of science." They did much to make possible the modern electric transformer. Truly they have helped to light the path of man, and to ease his burden.

The author has brought to us the story of how these men stuck with an idea until it bore fruit. H. T. B.

**Charles M. Hall and Aluminum.** *Laboratory*, **2,** 35 (1929).—A short account of Hall's discovery of the electrolytic production of aluminum. A full-page illustration of the aluminum memorial to Charles Martin Hall presented to Oberlin College by Richard B. Mellon faces the article. R. L. H.

**The Aluminum "Crown Jewels."** *Laboratory*, **2,** 36 (1929).—An illustration with brief description of an exhibit of the specimens which form the historical background of aluminum in America. Some of the small buttons of aluminum which Hall had in his hands when he rushed into Dr. Jewett's laboratory and announced that "he had it" are included in this exhibit. R. L. H.

**The New Chemical Laboratories of Harvard University.** A. B. LAMB. *Harvard Alumni Bull.*, **31,** 799–814 (Apr. 18, 1929).—A fifteen-page article, illustrated by eleven photographs of exterior and interior views, describing the New Mallinckrodt Chemical Laboratory may be found in the April 18 number of the *Harvard Alumni Bulletin*. This article is written by the director, Professor A. B. Lamb. S. W. H.

## EDUCATIONAL MEASUREMENTS AND DATA

**Tests and Visual Education.** A. HARN. *Educ. Screen*, **8,** 166 (June, 1929).—Tests are looked upon as instruments for determining the efficiency of instruction. To have validity the test must be defined by the aims and objectives of education.

Visual education looks to its effectiveness as a sanction for its continuance. So the tests used in measuring its effectiveness are basic in experimentation with this aspect of education.

Tests are reckoned valid if they: (1) measure achievements of educational objectives, or if (2) they measure achievements which have a high degree of correlation with those objectives.

Knowledge may be directly usable by the student either in the present (or later life) or it may be valuable in education because of its usefulness in developing attitudes, ideals, appreciations, and sympathies. The paramount contribution of visual education is to the second of the above uses. Direct and convenient tests for these ends are not at present known. Tests commonly employed have not shown a dependable correlation with these indices of "culture," "character," and the "liberally educated man."

Tests designed especially for visual instruction are needed. Such tests would, among other things, magnify the visual method of instruction in the minds of its teacher-users. B. C. H.

**Leisure Reading of Junior High-School Boys and Girls.** J. JENNINGS. *Peabody J. Educ.*, **6**, 333–47 (May, 1929).—"Proper use of leisure" is one of the seven cardinal aims of secondary education. The right kind of reading should further other of these aims including ethical conduct, worthy home membership, and good citizenship.

In an endeavor to learn the nature of the leisure reading of Knoxville (Tenn.) junior high-school boys and girls the author, assisted by junior high-school English teachers, obtained the reading records and some reading preferences of 890 junior high-school pupils; 375 boys and 515 girls. Results were tabulated separately for boys and girls.

Records are presented showing types of newspaper and magazine reading done, names of magazines and books read, and the magazine and book preferences.

Of interest to science teachers, *Popular Science* has fourth place in the preference list of the boys, *Science and Invention* stands sixth, and *National Geographic* has ninth place. No magazine of a scientific turn finds a place among the highest ten preferences of the girls. B. C. H.

**Secondary Education as a Field for Research.** W. C. REAVIS. *Phi Delta Kappan*, **12**, 21–4 (June, 1929).—The period 1925–27 shows a 188% increase of degrees granted for investigations in secondary education over the two years, 1923–25, preceding. From partial reports for 1927–28, 114 more theses on secondary education were completed for the one-year period than for the total four-year period, 1923–27.

Some phases of secondary education already partially studied include curriculum, extra-curricular activities, personnel administration, school costs, and experimental teaching.

References are cited to typical pieces of such work and bibliographies of such investigations are appended. B. C. H.

## THE METHODS AND PHILOSOPHY OF EDUCATION

**High-School Limitations.** EDIT. *High-Sch. Quart.*, **17**, 160 (July, 1929).—Small school principals cannot be expected to keep up with ever-varying unit requirements of twenty to forty colleges. They must consider financial limitations and limitations of teachers as to preparation, teaching load, and pupil load. College entrance is only one of several needs to be satisfied. Accredited schools will all give 16 units as defined by the Associations. Colleges can take graduates or not on what is offered and certified. The school must give courses which it can best do within the limitations mentioned above. J. H. G.

**Summer High-School Credits.** EDIT. *High-Sch. Quart.*, **17**, 161 (July, 1929).—There seems to be some irregular certification of high-school pupils doing summer work. There are two kinds of students doing summer work, those who have failed in a subject and are repeating it, and those who are pursuing a new subject. Forty-five days of summer school sessions or at least six weeks are suggested; no pupil should be allowed to carry more than two half-units of new work and with this carry no review work; no more than one unit of review work should be carried in a single term; recitation periods should be 60 minutes. J. H. G.

**Books and Their Use.** EDIT. *Harvard Alumni Bull.*, **31**, 1054 (June 13, 1929).—One of the symptoms in change in methods of college teaching is the decline in the use of "textbooks." This pedagogic artifice represented the view that knowledge was a finished thing that could be parcelled out in sealed packages bearing the trademark of authority. It implied that the teacher was a retailer or distributor of the product and that the student was the consumer, both being clearly distinguished from the manufacturer.

The new idea is that knowledge is in a state of perpetual flux and development, and that teachers and even students participate with investigators in this process. To be understood, knowledge has to be re-thought, whether by the teacher who imparts it or by the student who receives it, and this act of re-thinking has in it something of that critical or creative originality which distinguishes research.

The passing of the textbook means that students to an increasing extent resort directly to classics, to fundamental treatises, and even sources. This has led to the multiplication of standard works in convenient editions at low prices, and to the greatly increased use of libraries. For this service the American libraries were happily prepared by the enlightened methods which had already been for some time in vogue. At a gathering recently held to celebrate the completion of thirty years of service by Herbert Putnam, '83, as Librarian of Congress, Congressman Robert Luce, '82, described the earlier idea, which was accepted when he and Mr. Putnam attended Harvard together, an idea which even yet survives in continental Europe. John Langdon Sibley was then librarian at Harvard. On a certain Sunday afternoon, as he was locking up, with a smile of satisfaction on his face, a friend asked him why he felt so pleased. He answered, "Every book but one is in its place on the shelf. Agassiz has that one and I am going after it now."

A great university is both a treasure and form of service. S. W. H.

## PROFESSIONAL

**The Wages of Teaching.** *Technology Rev.*, **31,** 153–4 (Jan., 1929).—A recent study (*Occasional Papers, Number 8*) conducted by the General Education Board has revealed significant facts about salaries in American Colleges, particularly for the years 1926–27. In the 302 colleges of arts, literature, and science and corresponding colleges or departments of universities located in all parts of the country with which this study was concerned, the average salary of all grades of college teachers in all types of colleges was $2958. This figure represented an increase of 29.8 per cent over 1919–20.

To bring the facts nearer home, the average salary of all teachers, regardless of rank, in New England men's or co-educational institutions (women's colleges are lower) was $3605. The average at Massachusetts Institute of Technology during the current year is $3540, or 2 per cent less than the above figure of 1926–27 and 15 per cent more than the average in men's and co-educational institutions over the whole country.

In making comparisons with past years it should be kept in mind that these figures are, of course, based on nominal salaries. In what direction do they vary from real salaries? The Statistical Abstract of the United States, 1926, gives the index number of the cost of living in the United States, based on an average of 100 for 1913 as against 216.5 in June, 1920, and 175.6 in December, 1926. With this decrease in living cost, it is apparent that the salary increases are real increases over 1919–20.

Comparison with pre-war conditions, however, is not so encouraging. Using the above index figures and comparing the average salary in all types of colleges in all parts of the country, the author of the report computed the following table:

| | Nominal average salary | Real average salary |
|---|---|---|
| 1914–15 | $1724 | $1724 |
| 1919–20 | 2279 | 1114 |
| 1926–27 | 2958 | 1825 |

Says the report: "There was a distressing depreciation, it appears, in the real average salaries of college teachers from 1914–15 to 1919–20. The increase in 1926–27 over 1919–20 has been material and is gratifying. Nevertheless, despite all the efforts exerted in recent years to improve their economic status, teachers in the 302 institutions under consideration were only slightly better off financially in 1926–27 than like workers in 1914–15."

Deploring the low salaries paid in the teaching profession is nothing new. In "Galileo: His Life and Work," by J. L. Zahie (London: John Murray) there are interesting data on salaries and their attendant discontent in the teaching profession during the sixteenth and seventeenth centuries. Galileo accepted the mathematical professorship at Pisa on a salary of 60 scudi per annum, a scudo being equivalent to about $0.97. Later he had much difficulty in making ends meet at Padua where he first received 300 florins, or about $150 per annum. He was forced into much trouble getting this increased, and, in fact, received no increase of notable size until his development of the telescope prompted an admiring Venetian Senate to give him his professorship for life with a salary of 1000 florins, or a little less than $500 a year.

Unfortunately, no index figures were computed in those days, so it is impossible to reduce these nominal figures to real ones. But they attest the ever-present need for better economic conditions among academicians that is reflected in the study conducted by the General Education Board. S. W. H.

**How Industry Absorbs College Crop of Chemical Engineers.** J. A. LEE. *Chem. & Met.*, **36,** 415–6 (July, 1929).—"Registration in chemical engineering in our universities and colleges increased by more than 20 per cent last year. Sixty of the 80 institutions that give courses in chemical engineering reported a current output of 740 graduates. Of the number that went directly into industry the figures show that one in every six went into petroleum refining while only one in fifteen was absorbed by the strictly chemical industries. These and other interesting deductions and trends are revealed as the result of an extensive survey that *Chem. & Met.* has conducted through the cordial and effective coöperation of the chemical engineering departments of the principal colleges and universities of the United States."

Data is included in chart form on (1) distribution of chemical engineering graduates in the process industries and (2) chemical engineering registration statistics for 55 of the institutions giving courses in chemical engineering. R. L. H.

**The Qualifications of an Industrial Chemist.** F. A. FREETH. *Chem. & Ind.*, **48,** 647–50 (June 28, 1929).—The average college graduate is "crammed" to an extraordinary extent. Because most professors feel bound to give out research problems which will yield a definite result we find an atmosphere of artificiality around most post-graduate research. This sort of training may spoil otherwise good research men by causing them to expect certain results so that they do not observe keenly what really does happen when a new experiment is performed. The man intending to become an industrial chemist should pay much attention to the development of technic.

E. R. W.

## MISCELLANEOUS

**Home or Income.** *Harvard Alumni Bull.*, **31,** 1081–2 (June 30, 1929).—In the past year two serious attempts have been made to survey the practical, the material value of college education for women. One experiment was conducted at Radcliffe, the other at Columbia, and though like Tweedledum and Tweedledee, the final figures have proved themselves contrary-wise, the research has brought to light some surprising information.

At Radcliffe a study was made of the salaries of 1350 alumnae. As a unit of measure the median salary was chosen, that is, the salary earned by the middle person in any graded series. Analysis showed that the highest median salary—$2900—is earned by the Ph.D.'s; that the next highest median salary—$2500—is that representing some four hundred M.A.'s. The 772 holders of the A.B. degree have a $2000 median salary, while the median for the special students who have no college degree is $1900. Thus, say the college authorities, a Radcliffe woman's earning power increases in proportion to the amount of her education.

Professor Walter B. Pitkin of Columbia has started his research in the same direction but has fetched up at the opposite pole. According to his article in the current *North American Review* there are now 900,000 women in the United States whose mental caliber equals or surpasses that of the average college graduate—and there are jobs available for only 125,000 of them. "The intellectual woman's chance of finding work outside the home," he writes, "that will satisfy her superior mind is growing smaller every year, and not because of the antagonism of men but because such jobs are growing scarcer for everybody." He believes we are close to the saturation point. Banking cannot absorb more than 500 women in posts that require high intellectual ability; engineering, 400; journalism, 2000; medicine, 6000; teaching, 12,000; government service, 5000; scientific research, 10,000, and so on.

Between 1910 and 1920 there was an increase of only 26,834 women in the leading professions while the increase of those *qualified* to enter such fields was 130,000. The only natural recourse, says the statistician, is to motherhood, which, as we progress, will be regarded as "the greatest as well as the hardest of all the sciences."

From a casual review of these figures one is not to assume that the choice is between Radcliffe or matrimony. It might be nearer the truth to predict that in time to come the college type of woman, thanks to a labor-saving existence and the need for part-time work, will be better able to equate her intellectual ambition and her duty to the home.

S. W. H.

**Fathers and Sons.** EDIT. *Harvard Alumni Bull.*, **31,** 905 (May 9, 1929).—Many fathers have probably asked themselves from time to time whether their incomes and their intesrets, especially those fostered by their daily occupations, had any bearing on the attitudes of their sons toward academic work. Would sons do better in college if they realized the value of the dollar or if, on the other hand, they did not have to work to help pay their own tuition bills?

Answers to these questions are contained in "Incentives to Study," a book [for review see "Recent Books," THIS JOURNAL, **6,** 1371 (July-August, 1929)] recently published by Albert Beecher Crawford, Director of Personnel Study at Yale.

A greatly condensed statement of his findings based on elaborate statistical tabulations is here given.

1. Boys with limited financial means have higher college grades than those who have plenty of money.
2. This fact is not due to inferiority of the rich.
3. Poverty increases the chance that a boy will do as well as could be expected of him in view of his scholastic ability.
4. Sons of professional men tend to do better in college than sons of business men.
5. Sons of college parents are not superior as students to sons of non-college parents.

Of course, these conclusions are not absolutely accurate or reliable in all cases; they merely indicate general trends to which there are individual exceptions on each side. No one can say in advance about any boy whether he will do well or badly in college. Family background and other external factors have to do with each case. But, by and large, the chances are that affluence will be a deterrent rather than an aid; that a professional occupation on the part of the boy's father will help; and that it makes no difference whether or not the father and mother, or either, graduated from college.

S. W. H.

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**Russian Potash Developments.** An article appearing in a government publication of the Soviet Union states that the construction of new potash mines on the Upper Kama River is well under way. Two mines, No. 1 being developed by Soviet engineers and No. 2 by German potash specialists, are expected to be ready for exploration next spring. Effective exploitation of the Kama potash deposits involves several transport problems. Two-thirds of the potash mined, will, it is thought, be shipped down the Kama River; but this will be possible only after considerable dredging. Since an efficient fertilizer can be obtained only by mixing Kama potash with phosphates, it is very desirable to build a railroad connection between the Solikamsk potash deposits and the Kaigorod phosphate area. The railway connecting Usolie and Solikamsk, which is now under construction, will by no means solve the problem.—*Chem. Age*, **20,** 336 (April 6, 1929).

**Japanese Ammonium Sulfate Situation.** According to Japanese foreign trade statistics for 1926, Germany provided 300,000 tons, or 60 per cent of Japanese imports of ammonium sulfate, the United States taking second place with 20 per cent of the total, and Great Britain third, with 13 per cent. In 1927 the relation changed in favor of Great Britain, the German imports having declined to 81,673 tons, according to German statistics. Japanese production of ammonium sulfate is developing steadily. In 1927 it amounted to 180,000 tons, which was 34,000 tons more than during the preceding year. The total consumption is estimated at 500,000 tons. The future of the Japanese market for ammonium sulfate is influenced by the erection of large plants by the Japan Nitrogen Co., in Chosen, equipped for an annual production of 250,000 tons. These plants (like others in Japan) will work the Casale process. All the new plants, operating at capacity, would provide for the Japanese consumption of ammonium sulfate.—*Chem. Age*, **20,** 345 (April 6, 1929).

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Furfurol is manufactured in the United States to the extent of 500,000 lb. per annum. The price is 10–17 cents a pound, as compared with a price of 30 dollars per pound before 1922, when it was a chemical curiosity. In that year the U. S. Department of Agriculture began to investigate its technical production from agricultural waste products.

# Local Activities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' associations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

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**Wm. McPherson,** dean of the department of chemistry of The Ohio State University, has been chosen president-elect of the American Chemical Society. Circumstances arose which made it imperative for Doctor Parr to be relieved of some of his activities, and as a consequence he tendered his resignation as president-elect of the Society. Accordingly, as provided for in the Constitution, the office was filled from the other names on the ballot sent to the Council last November.

**Madame Curie,** the distinguished French scientist, was invested with the honorary degree of Doctor of Laws by the University of Glasgow on Wednesday, June 19th. On Thursday, June 20th, at a meeting of the Town Council, she was made a Guild Sister and Freeman of Glasgow.

**Results of Annual High School Chemistry Contest, Sacramento Section, A. C. S.** The following is a summary of the first seven Annual High-School Chemistry contests held by the Sacramento Section, A. C. S.

The first contest was held in Sacramento by assembling all contestants in one examination June 2, 1923. Seven schools competed with twenty-six individual students. The schools placed in the following order: Marysville, Auburn, Gridley, Stockton, Armijo, Anderson, and Vacaville. Francis Dempsey of Marysville made the highest individual score.

The second contest was held in Sacramento same as the first, May 31, 1924. Nine schools competed with thirty-two students. The schools placed in the following order: Chowchilla, Auburn, Dixon, San Juan, Ripen, Stockton, Marysville, Orland, and College City. Herase Bedford of Chowchilla was highest individual.

The third contest was conducted by sending the questions to each of the high-school principals, and all examinations returned to be graded by one committee. Ten schools competed in this contest and placed in the following order: Auburn, Modesto, Chowchilla, Turlock, Stockton, Nevada City, Woodland, San Juan, Dixon, and Merced. J. Wiley Ferribe of Auburn was the highest individual.

The fourth contest was conducted similarly to the third, May 21, 1926. Nine schools with thirty-six students competed. The schools placed as follows: Woodland,

Auburn, Stockton, San Juan, Yuba City, Placerville, College City, Williams, and Sacramento Evening High School. Jack Murata of Yuba City was highest individual.

The fifth contest was conducted same as third, May 20, 1927. Eleven schools with fifty-one students competed. The schools placed as follows: Yuba City, Woodland, Auburn, Winters, Davis, Sacramento, Placerville, Wheatland, Ripon, Tracy, and San Andreas. Carlton Foss of Yuba City was highest individual.

The sixth contest was conducted by sending examiners out to the schools simultaneously June 1, 1928. Fourteen schools with fifty-six students competed. The schools placed as follows: Lodi, Auburn, Galt, Roseville, Stockton, College City, Woodland, Ripon, Elk Grove, Ione, Courtland, Yuba City, and Sutter Creek. Thomas Oates of Sacramento was highest individual.

The seventh contest was conducted the same as the sixth, May 31, 1929. Fourteen schools and sixty students competed. The schools placed as follows: Auburn, Manteca, Stockton, Yuba City, Sacramento, Davis, Sutter Creek, Lodi, Roseville, Lincoln, San Juan, Grass Valley, Nevada City, and Tracy. Frederic Stafford of Roseville was highest individual.

Auburn is the only school to have competed every year, having won twice with four second places and one third and the highest individual once. Yuba City has competed four times, winning one first place for the school and two first places for highest individual. Marysville and Chowchilla have each won a contest with the highest individual. Woodland and Lodi have each won a contest. Sacramento and Roseville have each won the highest individual contest.

The following is a list of schools with the number of times each has competed: Auburn (7), Stockton (6), San Juan, Woodland, and Yuba City (4 each), College City, Ripon (3 each), Marysville, Chowchilla, Dixon, Placerville, Davis, Tracy, Lodi, Roseville, and Sutter Creek (2 each). The following schools have competed once each: Anderson, Armijo, Gridley, Vacaville, Orland, Modesto, Turlock, Nevada City, Merced, Grass Valley, Williams, Sacramento Evening, Lincoln, Winters, Sacramento, Wheatland, San Andreas, Manteca, Elk Grove, Ione, and Courtland.

The following schools have never competed: Jackson, Angel's Camp, Colusa, Maxwell, Princeton, Trucker, Folsom, Linden, Live Oak, and Esparto.

There are thirty-six high schools in this district. On the average 10.5 schools and 43.5 students compete. However, there is a gradual increase in the number of schools and students competing.

J. H. Norton, Sacramento Junior College, is Chairman of the Committee in charge of these contests.

**Battelle Memorial Institute.** A new center for scientific and industrial research in metallurgy and fuel is nearing the stage of active operation. The Battelle Memorial Institute, at Columbus, Ohio, was established in memory of Colonel John G. Battelle, by the will of his son, Gordon Battelle, 2d, and the endowment was later augmented by the will of Mrs. John G. Battelle. According to the will of Gordon Battelle, 2d, the Institute is to be devoted to research and education in coal, iron, steel, lead, zinc, and similar industries. It is a non-profit organization, its aim being public service through the furtherance of industry by the application of science.

The Institute's laboratory is located just across the street from the campus of Ohio State University. The front section of the first floor of the building, comprising the auditorium, library, museum, trustees' room, etc., is memorial in character, while the balance of the structure is of the laboratory type.

The laboratory was designed after careful study, by trustees and the architect, aided by Dr. Gerald Wendt, of many industrial university and government research laboratories, and incorporates many modern features of laboratory construc-

tion. The building contains some 60,000 square feet of floor space. Provision has been made for future expansion in the belief that industry will call for ultimate utilization of space for the accommodation of industrial fellows.

The income from the Institute's own endowment will be applied to general equipment and upkeep of the laboratory, and to research in metallurgy and fuels both from the point of view of pure science and of the study of industrial problems of broad economic import. More specific problems will be coöperatively studied on the industrial fellowship plan.

It will afford post-graduate training in pure and applied science to graduates in science and technology who serve on its staff or its fellowship staff. To this end it hopes to have the close coöperation of Ohio State University to work out arrangements whereby the staff may pursue courses for advanced degrees at the university, and whereby research work done at the Institute may be applied in partial fulfilment of the requirements for a degree.

Installation of equipment and selection of the technical staff is under way. No attempt will be made to operate on a large scale in the beginning. The building is now practically complete and in a few months the Institute should be operating as a going research organization and soon thereafter should be in shape to accept industrial fellowship work in its field.

Coöperation with other groups is also being arranged for. The Institute has agreed, contingent on the completion of the financing of the whole project, to underwrite one-third of the proposed expenditures of a total of $150,000 over a five-year period on the "Alloys of Iron Research," which is being sponsored by the Engineering Foundation, with the cooperation of the American Institute of Mining and Metallurgical Engineers, the other engineering societies, the Iron and Steel Institute, the steel industry and various universities and government laboratories.

The staff of Battelle Memorial Institute will also coöperate in the editorial and abstracting work of *Metals & Alloys* as an Institute project. Both the Alloys of Iron Research and the publication of *Metals & Alloys* are looked upon as steps in the application of science to the metallurgical industries, quite in keeping with the objects of the Institute. When the future research work of the Institute is ready for publication, not only *Metals & Alloys* but other scientific journals and transactions of technical societies will be offered papers for publication according to the suitability of the papers for a given set of readers.

While the work of the Institute is not restricted to metallurgy and fuels, it will concentrate on those specialties.

### American Electrochemical Society

Sept. 19th, 20th, 21st at Pittsburgh, Pa.

SYMPOSIUM ON CONTRIBUTIONS OF ELECTROCHEMISTRY TO AERONAUTICS

T. W. BOSSERT: "Use of Aluminum and Aluminum Alloys in Aircraft." (A general talk on the use of aluminum in aircraft showing characteristic sections, castings, etc.)

E. H. DIX, JR.: "Alclad Aluminum Alloys for Aircraft." (A discussion of Aluminum Company of America's duplex alloys known as "Alclad;" these consist of a strong alloy core with a surface coating of high-purity, corrosion-resistant aluminum.)

J. D. EDWARDS AND C. S. TAYLOR: "Electrolytic Potentials between Aluminum and Its Alloys." (Some experimental and practical data on the solution potential relationships of aluminum and its alloys will be presented. These data are of particular interest in connection with the Alclad alloys, where the pure aluminum coating is electronegative to and protects the core from corrosion.)

W. G. HARVEY: "The Use of Magnesium and Its Alloys in Aircraft Construction." (This is a general paper discussing the present and future possible uses of mag-

nesium in aircraft, and is more or less a companion paper to that of Dr. Frary on aluminum.)

*Discussion of above papers will be led by the following:*

MR. EDWARD P. WARNER, Editor of "Aviation."

DR. GEORGE W. LEWIS, Director of Aeronautical Research, National Advisory Committee for Aeronautics.

MR. STARR TRUSCOTT, Assistant to the Director of Research, National Advisory Committee for Aeronautics.

*Miscellaneous Papers*

1. "Electrothermic Production of Gray Iron and of Malleable Iron," by DR. G. L. SIMPSON of the Pittsburgh Electric Furnace Co.

2. "Chromium Plating," by DR. R. J. PIERSOL of the American Chromium Corporation, Wilkinsburg, Pa.

3. "Potentials against Corrosion Films," by DR. FRANK SPELLER, National Tube Company, Pittsburgh, Pa.

4. "Recent Developments in Electric Melting," by FRANK W. BROOKE, The William Swindell Corporation, Aspinwall, Pa.

5. "The Copper Oxide Rectifier," by DR. L. O. GRONDAHL, Union Switch and Signal Company, Swissvale, Pa.

6. "A New White Finish on Aluminum," and also "A New Explanation of Anodic Passivity in Sulfuric Acid," by MR. LEON MCCULLOCH, Westinghouse Research Laboratory, East Pittsburgh, Pa.

7. "A Sixty Cycle Coreless Induction Furnace Installation," by DR. PORTER H. BRACE, Westinghouse Research Laboratory, East Pittsburgh, Pa.

EXHIBITS OF RECENTLY DEVELOPED APPARATUS AND ELECTROCHEMICAL PRODUCTS

KAHLENBERG & KRUEGER—Potentiometric Titration.

T. D. YENSEN—Pure Iron.

ARTHUR S. KING—Electric Vacuum Furnaces.

SMITH & BRECKENRIDGE—Cathode Potentials of Copper.

MCCLURE & LOWRY—Preparation of Phenylhydrazine.

WILLARD & SCHNEIDEWIND—Chromium Plating Baths.

SHERLOCK SWANN—Caproic Acids.

STROCK & LUKENS—Tantalum Cathode.

N. A. ZIEGLER—Analysis of Carbon & Iron.

**Chicago Section, A. C. S.** The officers for the year 1929–30 were elected as follows: *Chairman*, W. V. EVANS, Chem. Dept. Northwestern University, Evanston, Ill. *First Vice-Chairman*, H. I. SCHLESINGER, Chem. Dept. University of Chicago, Chicago, Ill. *Second Vice-Chairman*, ROBERT CALVERT, Van Schaack Bros., 3358 Avondale Ave., Chicago, Ill. *Secretary*, W. M. HINMAN, Box 803, Chicago, Ill. *Treasurer*, A. B. CARTER, 460 E. Ohio St., Chicago, Ill.

*Elected Directors:* Terms expire July 1, 1931—D. K. FRENCH, DAVID KLEIN, S. L. REDMAN, E. H. VOLWILER, R. E. WILSON.

Terms expire July 1, 1930—MARY BAEVERTZ, B. E. SCHAAR, L. F. SUPPLE, PAUL VAN CLEEF, G. L. SCHNABLE.

*Immediate Past Chairman*, B. B. FREUD, 1242 Rosedale Ave., Chicago. *Editor of Bulletin*, DAVID KLEIN, 4221 S. Western Ave. *Managing Editor of Bulletin*, B. E. SCHAAR, 556 W. Jackson Blvd.

**Willard Gibbs Jurors**

Term expires 1930: A. D. Little, S. W. Parr, L. M. Tolman, E. W. Washburn.

Term expires 1931: B. S. Hopkins, W. Lee Lewis, S. C. Lind, J. Stieglitz.

Term expires 1932: Wilder D. Bancroft, George Borrowman, Otto Folin, F. C. Whitmore.

*Trustees:* D. K. French, term expires 1930; G. Thurnauer, term expires 1931; (one to be appointed by the Board of Directors).

*Councilors*, 1929: W. V. Evans, D. K. French, Wm. Hoskins, David Klein, S. L. Redman, B. E. Schaar, Paul Van Cleef, E. H. Volwiler, H. G. Walker, R. E. Wilson.

# Recent Books

**Experiments in General Chemistry.** H. W. STONE, Assistant Professor of Inorganic Chemistry, University of California, and M. S. DUNN, Associate Professor of Chemistry, University of California at Los Angeles. First edition. McGraw-Hill, Inc., New York City, 1929. xii + 107 pp. 12 figures. 14 × 20.5 cm. $1.00.

According to the preface, "this book is designed for the non-technical university student who desires general chemistry as a part of a liberal education." The authors state also that the book has been used in mimeograph form at the University of California for four years, and the experiments have been tried over a seven-year period. The assignments are designed to be covered in a one-year program of three hours per week. The book is divided into five parts as follows: **Part I.** *General Experiments*—Bunsen Burner, Glass Working, Density, Factors Influencing Rate of Reaction, Temperature Changes in Liquid-Gas and Liquid-Solid Transitions. **Part II.** *Weight Relations*—Water in a Hydrate, Combining Weights, and Formula Determination. **Part III.** *Volume Relations*—M. W. of Oxygen and Sulfur Dioxide, and Equivalent Weights. **Part IV.** *Solutions*—Effect of Temperature on Solubility, Fractional Crystallization, Ionization, Properties of Acids, Bases, Salts and Volumetric Analysis. **Part V.** *There are 13 assignments in this section.* Examples of these are: Chemical Equilibrium, Analyses of Baking Powders, Fractional Distillation, Hardness of Water.

The appendix is only three pages and does not include any of the usual tables. Among other things it includes an illustration of the graphic representation of data and brief first-aid instructions.

Each assignment is followed by a series of problems, usually six or seven in number.

It is difficult to understand why the authors chose the particular order for their material. The first experimental work is on glass bending, assuming no previous knowledge, and then Assignment 3 involves the use of acids of certain normality. In order to understand the third assignment, the student must have some knowledge of normality. Then later on, in Assignment 13, we find a simple experiment, as finding the solubility of a salt. The book does not include the usual experiments given to study the properties of the common elements.

The experiments are well written and for any one who desires a small manual on special topics, this should be an excellent book.

C. E. WHITE
UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

**Organic Chemistry for Students of Pharmacy and Medicine.** A. H. CLARK, Ph.G., B.Sc., M.S., Professor of Chemistry, University of Illinois, School of Pharmacy; Member of the General Committee of Revision of the Pharmacopeia of the United States; Past President of the American Conference of Pharmaceutical Faculties (American Association of Colleges of Pharmacy). D. Van Nostrand Company, New York, 1929. ix + 445 pp. 21 × 13 cm. $3.50.

It is the purpose of the author of this treatise to produce a text on the subject of organic chemistry that will adequately meet the needs of the student of pharmacy and medicine and also the prospective student of medicine. With this end in view, the author has included elaborate discussions of the chemistry of those products which are used medicinally and purposely omitted or touched on very

lightly, many of the dyes and other industrial substances which have little or no bearing upon the practising of these medical sciences.

The book is divided into three parts. Part one deals with open chain compounds; part two treats of the aromatic compounds, alkaloids, volatile oils and related products; part three includes the synthetic medicaments and certain other substances which do not properly belong in part one or two.

The textbook could in no sense of the word be looked upon as a philosophical treatise upon organic chemistry; on the other hand, it serves mainly as a descriptive text of organic substances used as medicines. Many of the theoretical considerations underlying the typical organic reactions are not found in this treatise. The descriptions and common names of such a vast number of organic substances as is included within this volume are indeed commendable and valuable to the student of pharmaceutical chemistry. The synthesis of many important pharmaceutical products which are of paramount importance to students of pharmacy and easily available in the literature of chemistry are omitted from the text. Notably among these are epinephrin, benzocaine and hexylresorcinol.

Many of the equations are not written in the generally accepted molecular form. Thus on p. 43, we find in an equation the term 8I; on p. 119, the terms 4 N and 2 N, whereas on p. 146 and 147 we find the terms $Na_2$ and $C_2$. Typographical errors occur in the book in several places, the spelling of iodine on p. 2, of rennin on p. 131, and of toluene on p. 170.

Finally, the book suggests itself to the mind of the reviewer as being commendable as a descriptive treatise of medicinal organic chemicals. In this respect it fulfils in part the purpose of the author. From the standpoint of academic chemical education, the book is incomplete and fails to adequately correlate related reactions and properties of organic compounds.

JOHN C. KRANTZ, JR.
UNIVERSITY OF MARYLAND, BALTIMORE, MD.

**Cases in the Administration of Guidance.** JOHN M. BREWER and twenty-two associates, members of research classes in the Graduate School of Education, Harvard University. First edition. McGraw Hill Book Co., Inc., New York City, 1929. xvi + 304 pp. 21 × 14.5 cm. $2.50.

The authors, using the case system, have selected "sample procedures in educational and vocational guidance" which would "give a comprehensive picture of the status of the movement." The first six chapters discuss educational guidance, the next six take up vocational guidance, a third group of five chapters considers counselors and their equipment for guidance, while the seven chapters of the fourth part discuss plans for various kinds of vocational and educational work, both in and out of school.

Thirteen of the co-authors are connected with public schools, three with private schools, and five with colleges and universities. The book is well adapted for use in schools of education and with study groups of persons interested in guidance work. Personnel problems in industry have been excluded. Doctor Brewer disarms partisanship with his disclaimer that "debate on educational principles will probably continue and will divide various groups into opposite camps representing various theories of life and education."

While the co-authors have realized their purpose fully, the reviewer feels that they have said at least ten words for the old educational scheme of academic high school and arts college to one for the vocational side of the problem. There are no applications to the field of chemical education. The book purposely avoids conclusions but leaves the cases cited open for discussion.

We must count the teeth of the horse, rather than take Aristotle's word for it. "We must stop making human junk" and it is unfortunate that too many "guiders" have had little or no experience with industry. Peter Cartwright once told a

young ministerial candidate that his vision of the words "P. C." meant "plow corn" rather than "Preach Christ." In as courageous a fashion we must tell our students that M. C. means not only Member of Congress, but "make chemicals."

R. E. BOWMAN
WILMINGTON TRADE SCHOOL
WILMINGTON, DELAWARE

**Mechanism of Enzyme Action and Associated Cell Phenomena.** F. F. NORD of the *Physiologische Institut, Tieraerzliche Hochschule*, Berlin. The Williams and Wilkins Co., Baltimore, 1929. 71 pp., 7 figs. Bibliography 7 pp. containing 189 references. 15 × 23 cm. $2.00.

The author has tried to give, in this small book, a brief survey of some of the more recent views and theories, including his own, concerning the chemistry of alcoholic fermentation, but does not attempt to discuss enzyme action in general as the title might suggest. A considerable part of the book's contents has already been presented in previous papers. [See *Chemical Reviews*, **3**, 41–79 (1926); *The Journal of Biological Chemistry*, **79**, 27–51 (1928); *Protoplasma*, **4**, 547–95 (1928)].

Among the more outstanding ideas brought forward may be mentioned: the way ethylene influences the colloidal condition of zymase, not only peptizing it but coating the surface and protecting it from the action of the end products of the reaction; and the plausibility of the Cannizzaro Transformation taking place between unlike aldehydes which might be present in the fermenting solution.

The reviewer has found the style of presentation rather involved, even tortuous and confusing in some places, and questions whether the author has succeeded in presenting, except to those thoroughly conversant with the literature of the subject, a very clear outline of our present knowledge in this interesting field.

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**Science and Progress in the Industries.** JOHN J. CARTY. Reprint and Circular Series of the National Research Council, No. 89. Washington, D. C., 1929. 8 pp. 17 × 25 cm. $0.20.

An address delivered before the National Electric Light Association Convention, June 5, 1929. The author points out, by giving numerous examples of men and the results of their labors, the value of research in applied science and the dependence of success of an industry upon its encouragement and support of research laboratories.

**Radio in Education.** ARMSTRONG PERRY. The Payne Fund, One Madison Avenue, New York City, 1929. 130 pp. 23 × 15 cm.

The Payne Fund is publishing this report to provide information for those who wish to use radio in education and who feel the need of facts on which to base investigation and activity.

Because the Fund's closest contact has been with the demonstration known as the Ohio School of the Air, and because it is believed that this successful effort provides the largest and best field for analysis in this country, the work in Ohio is described in detail. Inquiries received during the past few months led to the belief that many others would welcome an opportunity to learn how the Ohio demonstration was organized and operated.

It should be stated that all those who have coöperated in the Ohio demonstration realize that radio broadcasting for schools is in its infancy and that scientific research into methods and results must largely determine the nature and effectiveness of future broadcasting for schools.

**Bibliography of Bibliographies on Chemistry and Chemical Technology.** First Supplement, 1924–28. CLARENCE J. WEST AND D. D. BEROLZHEIMER, compilers. Bulletin of the National Research Council, No. 71. Washington, D. C., 1929. 161 pp. 17 × 25 cm. $1.50.

This *Bulletin* is a supplement to the Bibliography of Bibliographies on Chemistry and Chemical Technology, published in 1925 as *Bulletin* No. 50 of the National Research Council. Although most of the bibliographies listed have been published since 1924, many older ones have been included so as to make the united publication as complete as possible.

It is suggested that users in search of information consult both this *Bulletin* and *Bulletin* No. 50. Subject headings appearing for the first time have been indicated with an asterisk.

## BOOKS RECEIVED—LIBRARY OF CONGRESS, JUNE 22 TO AUGUST 14, 1929

**Arvin, James Augustus,** The Synthesis of certain cyclopentenyl and certain cyclopropyl substituted aliphatic acids. Urbana, Ill., 1928. 6 pp. 24 cm. Abstract of thesis (PH.D.)—University of Illinois, 1928.

**Barrett, William Henry,** Chemistry. Oxford, The Clarendon Press, 1927. viii, 151, 1 p., illus., 2 pl., fold. tab., diagrs. 19 cm.

**Bauer, Karl Hugo,** Die trocknenden öle. Stuttgart, Wissenschaftliche verlagsgesellschaft m. b. h., 1928. 5 p. l., 5–354 pp., illus., diagrs. 24 cm.

**Bollenbach, Hermann Fr., and E. Kieffer,** Laboratoriumsbuch für die tonindustrie. Halle (Saale), W. Knapp, 1929. viii, 96 pp., illus. 24 cm.

**Butler, John Alfred Valentine,** The fundamentals of chemical thermodynamics. London, Macmillan and Co., Limited, 1928. v. diagrs. 19½ cm.

**Carter, Albert Smith,** Synthesis of-heptane dicarboxylic acid—1, 5. Easton, Pa., 1928. 2 pt. 23½ cm. Thesis (PH.D.)—University of Wisconsin, 1927.

**Cornell, Elton Fred,** The carbazylic acids: the ammonia analogs of the carboxylic acids. Easton, Pa., 1928. Cover-title, pp. (3311)–3318. 23½ cm. From a thesis submitted to the Department of chemistry and the Committee on graduate study of Stanford university in partial fulfilment of the requirement for the degree of doctor of philosophy, 1926.

**Darmois, Eugène,** Leçons sur la conductibilité des électrolytes, professées à la Sorbonne en 1927–28. Paris, Vuibert, 1929. 2 p. l., 145 pp., illus., diagrs. 25 cm.

**Davies, Letha Allison.** I. The structures of convolvulinolic and jalapinolic acids. II. The preparation of certain dicyclohexylalkyl acetic acids. Urbana, Ill., 1928. 6 pp. 23 cm. Abstract of thesis (PH.D.)—University of Illinois, 1928.

**Draper, Hal Daniel,** The pore volume of the catalysts manganese dioxide, copper oxide, and mixtures of these oxides. Easton, Pa., 1928. 1 p. l., pp. 2637–53. illus., diagrs. 23½ cm. Thesis (PH.D.)—University of California, 1922.

**Foster, William,** Inorganic chemistry for colleges; a textbook for students of second year chemistry. New York, D. Van Nostrand Company, Inc., 1929. viii, 837 pp., front., illus., plates (1 col.) ports., diagrs. 22½ cm.

**Greene, Richard Daniel,** The reactivity of the methylated sugars. III. The action of dilute alkali on tetramethyl-d-mannose. Easton, Pa., Mack Printing Co., 1928. 15 pp., diagrs. 26 cm. Thesis (PH.D.)—Northwestern University, 1928.

**Gustus, Edwin Lyle,** Dissociation in the methylated sugars. A study of the action of alkaline hydrogen peroxide solution on tetramethyl-d-glucose. Easton, Pa., Mack Printing Co., 1927. 12 pp. 26½ cm. Thesis (PH.D.)—Northwestern University, 1926.

**Hart, Charles Vinton,** 1894–1928, Carbonic acid azides, by Charles Vinton Hart. Easton, Pa., 1928. Cover-title, pp. 1922–30. 23½ cm. Abstract of thesis (PH.D.)—Leland Stanford Junior University, 1927.

**Haworth, Walter Norman,** The constitution of sugars. New York, Longmans,

Green & Co.; London, E. Arnold & Co., 1929. vii, 100 p. ii pl. (incl. front.) diagrs. 23½ cm.

**Henle, Franz Wilhelm,** Anleitung für das organisch - chemische praktikum. Leipzig, Akademische verlagsgesellschaft m. b. h., 1927. xii, 308 pp., illus., diagrs. 22½ cm.

**Hibbert, Harold, and C. Pauline Burt.** Studies on reactions relating to carbohydrates and polysaccharides. XIII. Properties of gamma-delta-dihydroxycarbonyl derivatives and their bearing on the polymerization of polysaccharides. Easton, Pa., 1928. Cover-title, p. (1411)–1416. diagrs. 23½ cm. "Constructed from the dissertation presented by C. Pauline Burt to the faculty of the Graduate school of Yale University, June, 1925, in candidacy for the degree of doctor of philosophy."

**Hill, Arthur Joseph, and Floyd Tyson.** Studies on the preparation of the higher acetylenes. 1. (Preliminary paper.) Dehalogenation of 1,1-dichloroheptane in the vapor phase. Easton, Pa., 1928. Cover-title, pp. (172)–177. 1 illus. 23½ cm. F. T. Tyson's dissertation (PH.D.)—Yale University, 1923.

**Houben, Joseph,** Das anthracen und die anthrachinone mit den zugehörigen vielkernigen systemen. Leipzig, G. Thieme, 1929. xxiii, 890 p. incl. tables, diagrs. 26 cm.

**Hyde, James Franklin,** I. Some synthetic homologues of ephedrine. II. Study of the structural isomerism of certain diphenyl derivatives. Urbana, Ill., 1928. 7 pp. 23 cm. Abstract of thesis (PH.D.) —University of Illinois, 1928.

**Jabir ibn Haiyan,** *al Tarasusi.* The works of Geber, Englished by Richard Russel, 1678. A new edition with introduction by E. J. Holmyard. London & Toronto, J. M. Dent & Sons, Ltd.; New York, E. P. Dutton & Co., Inc., 1928. xl, 264 pp. incl. front. (facsim.) illus. 19½ cm. "The English translation was published in 1678, and is here reprinted with addition of figures taken from the Latin edition published at Berene in 1545." Contains reproductions of the title pages of the Latin edition of 1545 and of the English translation of 1678.

**Jones, George William,** Inflammability of Mixed Gases. Washington, U. S. Govt. Print. Off., 1929. iv, 38 p. incl. 1 illus., tables, diagrs. 24½ cm. U. S. Bureau of Mines. Technical paper 450.

**Knop, Johann August Ludwig Wilhelm.** Körpermolecule. Nachweisung der thatsache, dass die molecule der neueren chemie durch zusammenlegen von tetraedern und oktaedern atomistisch nachgebildet werden können, von prof. Wilhelm Knop. Leipzig, Commissionsverlag von L. Staackmann, 1876. 1 p. l., ii, 46 pp. 24 cm.

**Mason, Clyde Walter,** Microscopic chemical reactions of the acids of chlorine, bromide and iodine. Vienna, 1928. 1 p. l., 17, 10 pp. 23 cm. Thesis (PH.D.) —Cornell University, 1924.

**Mathias, Louis J., Jr., and R. S. Weiser.** Unit study and laboratory manual of chemistry. Toledo, 1928. 3 p. l., 3–234 pp., illus. 28 cm.

**Mayer, Albert Willy,** *Editor.* Chemisches fachworterbuch, deutsch-englisch-französisch, für wissenschaft, technik, industrie und handel. Leipzig, O. Spamer, 1929. 8 p. l., 825 pp. 25½ cm.

**Meade, Richard Kidder,** The chemists' pocket manual; a practical handbook containing tables, formulas, calculations, information, physical, and analytical methods for the use of chemists, chemical engineers, assayers, metallurgists, manufacturers and students. 4th ed. Easton, Pa., The Chemical Publishing Company; Tokyo, Japan, Maruzen Company, Ltd., 1929. 1 p. l., 533 pp. incl. illus., tables, diagrs. 16½ cm.

**Montillon, George Hamilton,** Rate of growth of crystals in aqueous solution. Ann Arbor, Mich., 1927. Cover-title, 21 pp. illus., diagrs. 23½ cm. Thesis (PH.D.)—University of Michigan, 1926.

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**O'Donnell, David Charles,** The mechanism of carbohydrate oxidation: the action of alkalies on *d*-mannose and *d*-glucose. Columbus, 1929. 20 pp., 1 l. diagrs. 24½ cm. Thesis (PH.D.)—Ohio State University, 1927.

**Oppenheimer, Karl,** Grundriss der anorganischen chemie mit besonderer berücksichtigung der allgemeinen chemie. Leipzig, G. Thieme, 1927. vii, 332 pp. diagrs. 19½ cm.

**Ott, H.** Strukturbestimmung mit röntgeninterferenzen. Leipzig, Akademische verlagsgesellschaft m. b. h., 1928. xii p., 1 l., 433 pp. incl. illus., tables, diagrs. vii pl. 25 cm.

**Pauling, Harry,** Elektrishe luftverbrennung. Halle (Saale), W. Knapp, 1929. 4 p. l., 188 pp. illus., diagrs. 24 cm.

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**Salzberg, Paul Lawrence,** The stability of hexa-substituted ethanes: hexa-tert.-butyl-ethynylethane. Urbana, Ill., 1928. 7 pp. 23 cm. Abstract of thesis (PH.D.) —University of Illinois, 1928.

**Simington, Robert Merrill, and Homer Adkins.** The catalytic oxidation with air of ethyl, isopropyl and *n*-butyl alcohols. Easton, Pa., 1928. Cover-title, pp. 1449–1456. 1 illus. 23½ cm. Thesis (PH.D.) —University of Wisconsin, 1927.

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**Spencer, Hugh Miller,** Solubility of lead monoxide and basic lead carbonate in alkaline solutions. Easton, Pa., 1928. 1 p. l., pp. 1572–1583. diagrs. 23 cm. Thesis (PH.D.)—University of California, 1924.

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**Stone, Hosmer Ward and M. S. Dunn.** Experiments in general chemistry. 1st ed. New York, McGraw-Hill Book Company, Inc., 1929. xii, 107 pp. illus., diagr. 21½ cm. $1.00.

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1526–1534. diagrs. 23½ cm. Thesis (PH.D.)—University of California, 1925.

**Wagner, Alfred,** Die parfümerieindustrie; nachschlagebuch für den parfümeur, chemiker, apotheker, drogist und seifenfabrikant, unter berücksichtigung der gesamten literatur und patente. Halle (Saale), W. Knapp, 1928. xi, 596 pp. incl. illus., forms. 24½ cm.

**Wardlaw, William, and Frederic William Pinkard.** Qualitative analysis. London, New York, etc., Longmans, Green, and Co., Ltd., 1928. vii, 166 pp., illus. 19 cm.

**Wellings, Alfred William,** Volumetric analysis; a practical course based on modern theoretical principles. London, Methuen & Co., Ltd., 1928. xi, 196 pp. illus. 19½ cm.

**Wiig, Edwin Odde,** Carbon dioxide cleavage from acetone dicarboxylic acid. Ithaca, N. Y., 1928. Cover-title, pp. 961–981. diagrs. 26½ cm. Abstract of thesis (PH.D.)—University of Wisconsin, 1927.

**Wilson, John Arthur,** Chemistry and leather. New York, Columbia University Press, 1929. 39 pp. incl. illus., port. 23½ cm.

**Winkler, Clemens Alexander,** Lehrbuch der technischen gasanalyse. Kurzgefasste anleitung zur handhabung gasanalytischer methoden von bewährter brauchbarkeit. 2 aufl. Freiberg, Engelhardt, 1892. xii, 200 pp. incl. illus., tables. 23½ cm.

**Wolfrom, Melville Lawrence,** The reactivity of the methylated sugars. II. The action of dilute alkali on tetramethyl glucose. Easton, Pa., Mack Printing Co., 1928. 20 pp., 1 l. diagrs. 26 cm. Thesis (PH.D.)—Northwestern University, 1927.

**Young, Philena Anne,** I. The volumetric determination of vanadium and chromium in special alloy steels. II. Ceric sulfate as a volumetric oxidizing agent. Easton, Pa., Mack Printing Co., 1928. 81 pp., 1 l. diagrs. 25½ cm. Thesis (PH.D.)—University of Michigan, 1928.

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**Basel. Universität,** Festschrift zur einweihung des Bernoullianums der Anstalt für physik, chemie und astronomie in Basel am 2. juni 1874, im auftrag der Universitætsregenz verfasst von Eduard Hagenbach ... und Julius Piccard ... Basel, C. Schultze, 1874. 2 p. l., 22 pp., 1 l., 35 pp. 28 cm.

**British** chemical abstracts; issued by the Bureau of chemical abstracts. B.—Applied chemistry. 1926–. London, 1926. v. illus. 27½ cm.

**Cinquantenaire** scientifique de M. Berthelot, 24 novembre, 1901. Paris, Gauthier-Villars, 1902. 2 p. l., 1862 p. front., plates (1 double, 1 col.) ports., facsims. 28½ cm.

**Mallinckrodt Chemical Works,** Chemistry of photography including developing, fixing, toning, reduction, intensification. St. Louis, New York, etc., Mallinckrodt chemical works, 1929. iii, 65 pp. diagrs. 21½ cm.

**U. S. Bureau of Engineering.** Instructions for the operation, care and repair of distilling plants. (Reprint of chapter 16 of the Manual of engineering instructions), Navy department, Bureau of engineering. Washington, U. S. Govt. print. off., 1929. 1 p. l., 48 pp. incl. illus., tables, diagrs. 3 fold pl. 23½ cm.

**U. S. Congress.** *Senate. Committee on agriculture and forestry,* Disposition of Muscle Shoals Report. Washington, U. S. Govt. Print. Off., 1929. 16 pp. 23½ cm.

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The production of methyl alcohol in the United States in April amounted to 732,000 gallons, as compared with 714,000 in the previous month.